

Supporting Information

Optimising Digital Twin Laboratories with Conversational AIs: Enhancing Immersive Training and Simulation through Virtual Reality

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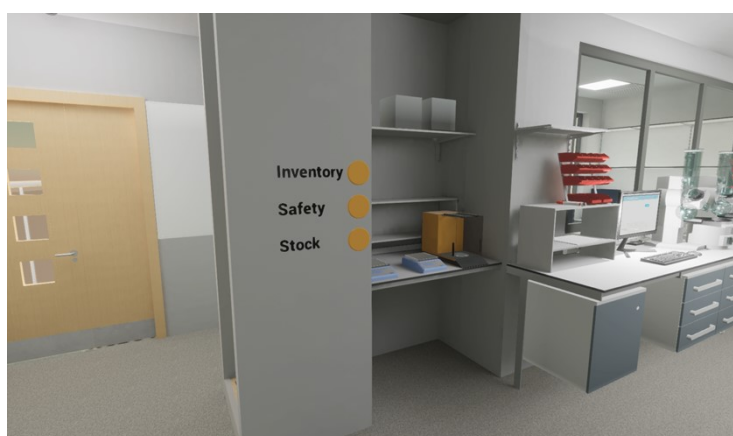
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S.1 LAB 427 Digital Twin Laboratory

The LAB 427 Digital Twin Laboratory is an exact replica of a research laboratory based at UCL School of Pharmacy, that was created leveraging existing CAD model of laboratory infrastructure and equipment, Autofusion (Fusion 360), and Unreal Engine 4.27. It was packaged for both Android (Quest 2/3), and PC. Much of the equipment in the software such as the 3D printers (Formlabs 2, Ultimaker) were designed as digital twins using exact measurements in Tinkercad, followed by transfer to Autodesk Fusion 360 software for conversion to their FBX files prior to import into Unreal Engine.



Supplementary Figure 1:(Left) Lab427 login screen and (Right) Initial environment upon entering Lab427 VR Software.



Supplementary Figure 2: Buttons to load in the avatars, that can be pushed using the left-click on PC software, or trigger button on Quest 2/3 software.

The VR laboratory is designed to directly replicate the actual laboratory, with the exact same layout as the research laboratory. Avatars could be directly placed into the existing LAB427 software in Unreal Engine due to the ConvAI Unreal Engine plugin, using a unique 16-digit character code. In the software, avatars are loaded via yellow buttons (see Figure 2) and can be spoken with by pressing either the 'B' key on the PC software, or the X button on Quest 2 and Quest 3 hand-controllers.

S1.2 Development of the Digital Twin Laboratory

In order to build the digital twin laboratory of LAB427, the drawing plans of the laboratory were first obtained as the planar floor plans that are typically available from most architects. This was then transferred as a picture file to Unreal engine, laid flat as a plane on the floor and walls and associated architecture added to the Unreal engine map (Unreal engine 4.27).

S1.3 Access to LAB427 Software

For access to the software minus the AI avatars described in this work and working examples of equipment, drawing pens, molecular models, visit <https://sidequestvr.com/app/9900/lab427-digital-twin>.

For full access to the software including access to AI avatars, real time laboratory data, 3D Printing training, group posters, 3D drawing pens, and remote global access and multiplayer sessions, please email s.hilton@ucl.ac.uk.

S.2 ConvAI

ConvAI is a web-based interface for the development of conversationally enabled artificial intelligence (AI) powered avatars and can be accessed via the URL: <https://convai.com/>. Characters were created using the web-based application, including the customisation of features including backstory, voice, knowledge bank, and appearance. The characters can then be integrated into existing applications using a series of plugins, including plugins for Unity (<https://unity.com/>), Unreal Engine (<https://www.unrealengine.com/en-US>), and others.

S.3 Knowledge Banks

Knowledge Banks are used by ConvAI to train characters on specific information and prevent the generation of generic responses. The following Knowledge Banks were inputted into each character as plain text (.txt) files.

S.3.1 SAM

The Knowledge Bank for SAM contained two differently formatted plain text files of a list of chemicals stored in Lab427, with their location, sub location, CAS number, and local stock code. The three formats included:

1. The list in original format directly exported from LabSuit chemical inventory navigation database, with supplementary information (supplier codes, quantity in stock) removed.
2. The list reformatted so that each item was separated by a blank line.

Full text files have been omitted from this Supplementary Information, due to the sheer assize of the lab database and to ensure safety. for more information please contact the Corresponding Author.

S.3.2 InGRID

Laboratory 427 Equipment Inventory

- By location:

- Personal work stations
 - Needles and syringes
 - Gloves
 - Septas
 - Waste bins
 - Sharps bins (in fumehoods)
- Above FormLab 3D printers
 - TLC plates and associated equipment
- Beside the shower
 - Parafilm
 - Aluminium foil
- Above the balances
 - Asynt DrySyn Kit
- Shelf 1
 - Conical flasks <250mL
 - Small beakers
 - Funnels
 - Measuring cylinders
 - Duran bottles
- Shelf 2
 - Conical flasks >250mL
 - Buchner flasks and funnels
- Storage drawers 1
 - Top
 - Adapters
 - Middle
 - Round bottom flasks

- Bottom
 - Dean Stark glassware
- Storage drawers 2
 - Top
 - Adapters
 - Spatulas
 - Middle
 - Round bottom flasks
 - Bottom
 - Arduino kit
- Storage drawers 3
 - Top
 - Swan neck adapters
 - pH test strips
 - Spare taps
 - Middle
 - Distillation glassware
 - Separating funnels
 - Bottom
 - Gilson pipettes
 - Pipette tips.
- Storage drawers 4
 - Top
 - Flow kit
 - Middle
 - Round bottom flasks
 - Bottom
 - Liebig condensers
- Next to Chemical Cupboard 2
 - Spare lab coats

No other information provided.

S.3.3 SUSAN

The following Health and Safety documentation was uploaded to SUSAN's Knowledge Bank in plain text format.

S.3.3.1 Summary text

Laboratory 427 has several local codes of practice that you should be aware of:

1. Personal protective equipment is to be worn at all times in all chemistry laboratories including safety glasses and laboratory coats, gloves appropriate to the hazard (see risk assessments), and secondary containers for transport outside the laboratory.
2. Maintain good standards of general tidiness and lab hygiene. Long hair should be tied back or covered.
Loose clothing should be avoided.
Appropriate footwear should be worn.
Touching the skin should be avoided while handling chemicals.
Never pipette by mouth.
No eating, drinking, food storage, application of cosmetics, taking medication within laboratories. Food and drink transported in the corridors should be covered/sealed.
Cuts and abrasions should be covered with waterproof dressings.
Working alone in the laboratory is covered by a separate safety notice with which all members of staff should become familiar.
Working areas such as benches and fume hoods should be always kept clean and tidy.
3. Safety equipment must be maintained including emergency showers outside of Lab 427 and Lab 436, and first aid boxes. The building is adequately provided with fire extinguishers and employees should familiarise themselves with their location. For more specific information on local codes of practice for laboratory 427, refer to the document. In addition to the local codes of practice, a set of COSHH Process Assessments (CG1 to CG10 and CS1 to CS8) otherwise known as risk assessments have been created that covers the vast majority of laboratory processes that will be undertaken by students and staff in Laboratory 427. These assessments have been prepared as a "one-stop-shop" for any chemist wishing to use substances which fall within the described classes. It is recommended that chemists refer to the COSHH procedure assessments (CG1 to CG10 and CS1 to CS8) listed below for all the information required in handling classes of chemicals with identified hazards. This is updated on an annual basis.
 1. CG1 General Code of Practice
 2. CG2 Very Toxic, Carcinogenic, Mutagenic or Sensitizing

3. CG3 Pyrophoric Liquids
4. CG4 Water Sensitive Reagents
5. CG5 Oxidants
6. CG6 Potentially Explosive Materials
7. CG7 Pressurised Gases
8. CG8 Reactive Metal Hydrides
9. CG9 Hydrogenation
10. CG10 Ethers
11. CS1 Azides
12. CS2 Cyanides
13. CS3 Ozone
14. CS4 Phosgene
15. CS5 Phenols
16. CS6 TFA/TFAA
17. CS7 POCl₃
18. CS8 LiAlH₄

For specific information on dealing with any of the above hazards, refer to the relevant risk assessment document.

S.3.3.2 Risk Assessments

The following Risk Assessment documents were separately saved as plain text files and uploaded to SUSAN's Knowledge Bank:

1. CG1 General Code of Practice
Assessment Outline: This Assessment covers the handling and use of harmful, irritant, toxic, flammable or corrosive materials and UCL School of Pharmacy compounds where hazardous properties have not been fully investigated. It involves operations involving up to 1 mol as reagents or 2.5 litres as solvent and chromatography work for up to 5 Litres of solvent with the risk phrases as below: R20: Harmful by inhalation, R21: Harmful in contact with skin, R22: Harmful if swallowed, R40: Limited evidence of carcinogen effect, R48: Danger of serious damage to health by prolonged exposure, R62: Possible risk of impaired fertility, R63: Possible risk of harm to the unborn child, R65: Harmful: may cause lung damage if swallowed, R36: Irritating to eyes,

R37: Irritating to respiratory system, R38: Irritating to the skin, R41: Risk of serious damage to eyes, R43: May Cause sensitization by skin contact, R23: Toxic by inhalation, R24: Toxic in contact with skin, R25: Toxic if swallowed, R33: Danger of cumulative effects, R34: Causes burns, R35: Causes severe burns, R64: May cause harm to breast fed babies, R66: Repeated exposure may cause skin dryness or cracking, R67: Vapours may cause drowsiness and dizziness, R68: Possible risk of irreversible effects, R12: Extremely Flammable, R11: Highly Flammable, R10: Flammable.

2. CG2 Very Toxic, Carcinogenic, Mutagenic or Sensitizing

Assessment Outline: This Risk assessment covers the handling of very toxic, carcinogenic, teratogenic, mutagenic or sensitizing materials and UCL School of Pharmacy compounds identified as having potential for carcinogenic, teratogenic, mutagenic, sensitizing or very toxic effects in Chemistry laboratories where hazardous properties have not been fully investigated. Operations involving up to 0.1 mol as reagents or 500 mL as solvent with the risk phrases as below: R26: Very toxic by inhalation, R27: Very toxic in contact with skin, R28: Very toxic if swallowed, R39: Danger of very serious irreversible effects, R42: May cause sensitization by inhalation, R43: May cause sensitization by skin contact, R45: May cause cancer, R46: May cause heritable genetic damage, R49: May cause cancer by inhalation, R60: May impair fertility, R61: May cause harm to the unborn child, R62: Possible risk of impaired fertility, R63: Possible risk of harm to the unborn child, R64: May cause harm to breast-fed babies.

3. CG3 Pyrophoric Liquids

Assessment Outline: It covers the handling of pyrophoric liquids in Chemistry Laboratories. This includes all liquids carrying the risk phrase R17. As any exposure of the liquid to air will probably result in fire, any spillage and subsequent ignition presents the major risk. The liquids are also liable to be volatile and highly flammable organic compounds, and/or corrosive in nature. Secondary risks therefore arise from potential inhalation of vapours or via skin absorption due to contact with the liquid (reference must be made to other relevant COSHH assessments.) R17: Spontaneously flammable in air. For commercially available material, the MSDS should always be consulted in addition to the bottle label (which can be obsolete)

4. CG4 Water Sensitive Reagents

Assessment Outline: THIS RA HAS BEEN UPDATED IN RESPONSE TO COVID-19 This Assessment covers the handling of water sensitive reagents in Chemistry laboratories. Reactions involving up to a total of

1 mol of the water sensitive reagent with the risk phrases below are covered by this assessment. Solids are liable to be finely divided and extremely dusty, and as such present an inhalation hazard in addition to potential for skin and eye contact. Liquids are liable to be highly corrosive in nature. Solutions of reagents with the above properties are also liable to be highly flammable and volatile. The primary risk of exposure is therefore inhalation of dust or vapours or via skin absorption due to contact with the liquid (Reference must be made to other relevant COSHH assessments). This includes all reagents with risk phrases R14: Reacts violently with water R15: Contact with water liberates extremely flammable gases. R29: Contact with water liberates toxic gas. R31: Contact with acid liberates toxic gas. R32: Contact with acids liberates very toxic gas. For commercially available material, the MSDS should always be consulted in addition to the bottle label (which can be obsolete) R17: Spontaneously flammable in air. For commercially available material, the MSDS should always be consulted in addition to the bottle label (which can be obsolete)

5. CG5 Oxidants

Assessment Outline: THIS RA HAS BEEN UPDATED IN RESPONSE TO COVID-19 This Assessment covers the handling of oxidants in Chemistry laboratories Reactions involving up to a total of 0.5 mol scale limit with the risk phrases below are covered by this assessment. Solids are likely to be finely divided and extremely dusty, and as such present an inhalation risk in addition to potential for skin and eye contact. Liquids may be volatile, highly flammable organic compounds, and/or corrosive in nature. The primary risk of exposure is therefore via inhalation of dust, vapours or aerosols, or via skin absorption due to contact with the liquid. This assessment includes all reagents with risk phrases: R7: May cause fire. R8: Contact with combustible material may cause fire. R9: Explosive when mixed with combustible material.

6. CG6 Potentially Explosive Materials

Assessment Outline: THIS RA HAS BEEN UPDATED IN RESPONSE TO COVID-19 This Assessment covers the HANDLING OF POTENTIALLY EXPLOSIVE MATERIALS – CG6 Maximum Scale Limit- Handling of potentially explosive materials in Chemistry laboratories up to a 0.1mol limit. Risk of Exposure Solids are likely to be finely divided and extremely dusty, and as such present an inhalation risk in addition to potential for skin and eye contact. Liquids may be volatile, highly flammable organic compounds, and/or corrosive in nature. The primary risk of exposure is therefore via inhalation of dust, vapours or aerosols, or via skin absorption due to contact with the liquid. There is a risk of physical harm from an explosion. Unexpected

and violent reactions may cause glassware to shatter and other components of the chemical reaction to be scattered with force over a wide area. This assessment includes all reagents with risk phrases: R1: Explosive when dry R2: Risk of explosion by shock, friction, fire or other sources of ignition. R3: Extreme risk of explosion by shock, friction, fire or other sources of ignition. R4: Forms very sensitive explosive metallic compounds. R5: Heating may cause explosion. R6: Explosive with or without contact with air. R9: Explosive when mixed with combustible material. R16: Explosive when mixed with oxidising substances. R44: Risk of explosion if heated under confinement. For commercially available material, the MSDS should always be consulted in addition to the bottle label (which can be obsolete) When using azides reference to the Azide COSHH assessment must be made (CS1)

7. CG7 Pressurised Gases

Assessment Outline: This Assessment covers the handling of gases in Chemistry laboratories. Operations involving the use of pressurised gases and gas cylinders (excluding Hydrogen see risk assessment: CG9 (Hydrogenation catalysts)). IMPORTANT: This COSHH does not cover the use of gases with specific associated hazards. For those gases which do have hazards a specific COSHH assessment will need to be written if not already in place or covered by existing generic risk assessments For commercially available material, the MSDS should always be consulted in addition to the cylinder label. The primary risks from handling compressed gases and gas cylinders are physical and mechanical. At close range a stream of compressed gas from a large cylinder may pierce the eyeball. Also, large cylinders can cause crush injuries if dropped or mis-handled.

8. CG8 Reactive Metal Hydrides

Assessment Outline: This Assessment covers the handling of reactive metal hydrides (excluding LiAlH_4) in chemistry laboratories. Operations involving up to a 0.5 mol scale limit, except for KH where a 0.1 mol scale limit applies with the risk phrases as below: R15: Contact with water liberates extremely flammable gases R14: Reacts violently with water R20/21/22: Harmful by inhalation and toxic in contact with skin and if swallowed. For commercially available material, the MSDS should always be consulted in addition to the bottle label (which can be obsolete) All grades of commercial NaH may contain traces of sodium which render it spontaneously flammable in dry air and finely divided material will also ignite in dry air. The unpredictable nature of 95% NaH poses significant risk in its handling therefore 50 or 60% NaH is to be used as a dispersion in oil. Solids are liable to be volatile and highly

flammable organic compounds, and/or corrosive in nature. The primary risk of exposure is therefore via inhalation of vapours or via skin absorption due to contact with the liquid. Hydrogen gas is evolved, often exothermically. Can cause fire if exposed to air especially in the presence of flammable solvents. Sodium hydride can react uncontrollably with dimethylformamide above 26 C and all reactions involving this combination should be avoided if possible. - All reagents, solvents and apparatus should be dry. - Arrange weighing and additions so that any spillage is contained e.g within a glass dish.- All reactions should be conducted under dry, inert atmosphere within the temperature range -78 C to +65 C - When using dimethylformamide, dimethyl acetamide or dimethyl sulphoxide as the solvent keep the temperature of addition below 10 C and the reaction temperature below 50 C - Care should be taken to ensure all residual hydride has been destroyed before solvent extraction.

9. CG9 Hydrogenation

Assessment Outline: THIS RA HAS BEEN UPDATED IN RESPONSE TO COVID-19 This Assessment covers hydrogenation in Chemistry Laboratories. Description of process: Handling of hydrogenation catalysts in chemistry laboratories. Operations involving up to a total of 5g hydrogenation catalysts with the following risk phrases: R7: May cause fire R8: Contact with combustible materials may cause fire R11: Highly flammable R12: Extremely flammable R17: Spontaneously flammable in air For commercially available material, the MSDS should always be consulted in addition to the bottle label (which can be obsolete) Solids are liable to be finely divided and extremely dusty, and as such present an inhalation hazard in addition to potential for skin and eye contact. Liquids are liable to be volatile and highly flammable organic compounds, and/or corrosive in nature. The primary risk of exposure is therefore via inhalation of dust, vapours or via skin absorption due to contact with the liquid. Refer to other risk phrases associated with the catalyst for other risks e.g Raney nickel, Carcinogen category 3, R40: possible risk or irreversible effects, R43: may cause sensitisation by skin contact. Precious metal catalysts (except Raney nickel) are not initially pyrophoric but will become so when containing adsorbed hydrogen (i.e. when they have been used in a hydrogenation).

10. CG10 Ethers

Assessment Outline: This Assessment covers ethers and their use in the laboratory. Ethers are liable to be volatile and highly flammable organic compounds. The primary risk of exposure is therefore via inhalation of vapours or aerosols, or via skin absorption due to contact with the liquid. Operations involving up to 1 mol as reagents or 2.5 litres as solvent with the risk phrases as below: R10: Flammable R11: Highly flammable R12: Extremely flammable R19: May form explosive peroxides R22: Harmful if swallowed R66: Repeated exposure may cause skin dryness or cracking R67: Vapours may cause drowsiness and dizziness For commercially available material, the MSDS should always be consulted in addition to the bottle label (which can be obsolete) This assessment should be read along with the following COPs and SOPs COSHH Codes of Practice for the Handling of Substances which are Irritant, Harmful, Corrosive or Toxic Code of Practice for the Handling and Disposal of Carcinogens COP1 - Waste Disposal, COP 6 – Liquefied Gases and Solid carbon dioxide COP 9– Use of Fume Cupboards COP 21 - General Code of Practice for Laboratories COP 17 -Drying Laboratory Glassware COP 13- Working Alone.

11. CS1 Azides

Assessment Outline: This Assessment covers the handling of azides in the laboratory. The primary risk of exposure is therefore via inhalation or by skin contact. Exposure may affect blood pressure (profound lowering) and heart rate. Unexpected and violent reaction may shatter glassware, scattering shards with force over a wide area. If not contained this gives a risk of cuts, burns and chemical hazards of the other components of the reaction. Consideration of the workplace exposure limits (WELs) associated with compounds having hazards classified as above suggest that the control measures described will give adequate worker protection if correctly implemented. Chemical risk phrases associated with the compounds covered by this assessment: R1: Explosive when dry R2: Risk of explosion by shock friction, fire or other sources of ignition R3: Extreme risk of explosion by shock friction, fire or other sources of ignition R4: Forms very sensitive explosive metal compounds R28: Very toxic if swallowed R32: Contact with acid liberates very toxic gases R36/37/38: Irritating to eyes, skin and respiratory system For commercially available material, the MSDS should always be consulted in addition to the bottle label (which can be obsolete). The handling of azides at a scale of up to 10 g (solid azides) or up to 0.1 mole of a liquid azide. For trimethylsilyl azide in an acidic environment, the scale covered by this assessment is limited to 0.01 mole (i.e. 10 mmol) It should be read along with the following COPs

and SOPs COSHH Codes of Practice for the Handling of Substances which are Irritant, Harmful, Corrosive or Toxic Code of Practice for the Handling and Disposal of Carcinogens COP1 - Waste Disposal, COP 6 – Liquefied Gases and Solid carbon dioxide COP 9– Use of Fume Cupboards COP 21 - General Code of Practice for Laboratories COP 17 -Drying Laboratory Glassware COP 13- Working Alone

12. CS2 Cyanides

Assessment Outline: The primary routes of exposure to cyanides are via inhalation, ingestion, or skin absorption. Exposure can cause lung irritation and cyanosis. symptoms include weakness, headache, confusion, nausea, vomiting and low gasping respiration. PRIOR TO THE USE OF CYANIDES: INFORM ALL LABORATORY WORKERS AND SUPERVISOR IN ALL INSTANCES. ALSO CONTACT THE APPROPRIATE FIRST AIDERS (Mr Adrian Rodgers) TO ARRANGE EMERGENCY FIRST AID COVER REQUIREMENTS. This assessment covers reactions involving up to 0.1 moles of cyanides. Risk phrases given below: R26: Very toxic by inhalation R27: Very toxic in contact with the skin R28: Very toxic if swallowed R32: Contact with acid liberates very toxic gas R34 Causes burns R38: Irritating to skin For commercially available material, the MSDS should always be consulted in addition to the bottle label (which can be obsolete) Solids are liable to be finely divided and dusty, presenting an inhalation hazard in addition to skin and eye contact. Liquids (e.g. trimethylsilyl cyanide) are liable to be volatile and flammable Toxic fumes may be released during evaporation Refer to the relevant local rules and codes of practice before commencing the procedure: COSHH Codes of Practice for the Handling of Substances which are Irritant, Harmful, Corrosive or Toxic Code of Practice for the Handling and Disposal of Carcinogens COP1 - Waste Disposal, COP 6 – Liquefied Gases and Solid carbon dioxide COP 9– Use of Fume Cupboards COP 21 - General Code of Practice for Laboratories COP 17 -Drying Laboratory Glassware COP 13- Working Alone.

13. CS3 Ozone

Assessment Outline: THIS RA HAS BEEN UPDATED IN RESPONSE TO COVID-19 This Assessment covers the use of ozone in Chemistry Laboratories. Ozone is not transported or stored, but is produced as needed with the ozone generator (ozoniser) Do not use reaction temperatures below -110 degC as this could result in condensation of explosive liquid ozone. Reaction temperatures of -78 to 0 degrees centigrade should suffice. Some methods require the preparation of a solution of ozone in dichloromethane at -78degC. Never prepare more of such a solution than is immediately required. Intermediate ozonides

should be regarded as explosive and must be further reacted in situ, they should never be isolated Risk Phrases as Below:

R8: Contact with combustible material may cause fire R26: Very toxic by inhalation R36: Irritating to eyes R37: Irritating to respiratory system For commercially available material, the MSDS should always be consulted in addition to the label (which can be obsolete) INFORM ALL LABORATORY WORKERS AND SUPERVISOR IN ALL INSTANCES PRIOR TO THE USE OF OZONE.

14. CS4 Phosgene

Assessment Outline: This Assessment covers the use of Phosgene and its equivalents. The risk of exposure is via inhalation. Fatal pulmonary oedema (secretion of fluid into the lung) may occur several hours after inhalation. INFORM ALL LABORATORY WORKERS AND SUPERVISOR IN ALL INSTANCES PRIOR TO THE USE OF PHOSGENE OR ITS EQUIVALENTS. It covers the handling of Phosgene and its equivalents in Chemistry Laboratories. Maximum scale- operations involving up to a total of 0.1 mol phosgene and its equivalents, above this, the Departmental Safety Officer must be informed prior to commencement of work. It should be read along with the following COPs and SOPs COSHH Codes of Practice for the Handling of Substances which are Irritant, Harmful, Corrosive or Toxic Code of Practice for the Handling and Disposal of Carcinogens COP1 - Waste Disposal, COP 6 – Liquefied Gases and Solid carbon dioxide COP 9– Use of Fume Cupboards COP 21 - General Code of Practice for Laboratories COP 17 -Drying Laboratory Glassware COP 13- Working Alone

15. CS5 Phenols

Assessment Outline: This Assessment covers the handling and use and handling of phenols in chemical laboratories at UCL School of Pharmacy where the hazardous properties of compounds may not have been fully investigated. Risk of Exposure: Phenols are extremely well and rapidly absorbed through the skin. The risk is highest when compounds are either in solution, liquid or molten form. Aqueous phenol is more readily absorbed through the skin than crystalline phenol. Therefore only use Phenosalve as a rinsing agent for the treatment of splashes of phenol and phenolic compounds from the skin. Wearing of a face visor is recommended and must be worn when handling more than 1.0 g of a phenolic compound as either a liquid or a solution. This figure is based on a worst-case scenario involving a phenol with an LD50 of 25 mg/kg (<25 mg/Kg would be a very toxic compound). 1.0 g of this phenol as a liquid or solution, if splashed and completely absorbed through the skin of a small chemist (40kg) has a

50% probability of resulting in death. In some cases, the use of an SOP compound containing phenolic functionality may not require the use of a face visor. However, this must be agreed following discussion with your supervisor. Maximum Scale: Operations involving up to a total of 1.0 mole of a phenol with risk phrases as below: Risk Phrases: R23: Toxic by inhalation R24: Toxic in contact with skin R28: Very toxic if swallowed R34: Causes Burns To be used with- COSHH Codes of Practice for the Handling of Substances which are Irritant, Harmful, Corrosive or Toxic Code of Practice for the Handling and Disposal of Carcinogens COP1 - Waste Disposal, COP 6 – Liquefied Gases and Solid carbon dioxide COP 9– Use of Fume Cupboards COP 21 - General Code of Practice for Laboratories COP 17 -Drying Laboratory Glassware COP 13- Working Alone

16. CS6 TFA/TFAA

Assessment Outline: This assessment covers the handling and use of TFA and TFAA in chemistry laboratories at UCL School of Pharmacy. It covers operations involving up to a total of 1 mole (i.e. 77 mL of TFA and 141 mL of TFAA) with risk phrases outlined below: TFA: R20: Harmful by inhalation, R35: Causes severe burns, R52/53: Harmful to aquatic organisms, may cause long term adverse effects in the aquatic environment TFAA: R14: Reacts violently with water, R20: Harmful by inhalation, R21: Harmful in contact with skin, R22: Harmful if swallowed, R35: Causes severe burns, R52/53: Harmful to aquatic organisms, may cause long term adverse effects in the aquatic environment.

17. CS7 POCl₃

Assessment Outline: This risk assessment covers operations involving up to 100 mL of phosphorus oxychloride with the risk phrases as below: R14: Reacts Violently with water R22: Harmful if swallowed R26: Very toxic by inhalation R29: Contact with water liberates toxic gas R35: Causes severe burns R48/23: Toxic danger of serious damage to health by prolonged exposure through inhalation For commercially available material, the MSDS should always be consulted in addition to the bottle label (which can be obsolete) Primary risk of exposure is via inhalation of vapours or via skin absorption due to contact with the liquid.

18. CS8 LiAlH₄

Assessment Outline: This risk assessment covers operations involving up to 0.5 mol of LiAlH₄ and its solutions with the risk phrases as below: R14: Reacts Violently with water R15: Contact with water liberates extremely flammable gas R20/21/22: Harmful by inhalation, in contact

with skin and if swallowed R34: Causes burns. LiAlH₄ solid is liable to be finely divided and extremely dusty, and as such presents an inhalation hazard in addition to potential skin and eye contact. LiAlH₄ solutions are liable to be volatile and highly flammable and corrosive in nature. The primary risk of exposure is therefore via inhalation of dust, vapours or via skin absorption due to contact with the liquid. LiAlH₄ reacts violently with a variety of organic and inorganic compounds. LiAlH₄ may react with evolution of heat on contact with moisture, releasing flammable hydrogen gas. LiAlH₄ is incompatible with acids, combustible materials, peroxides, halocarbons and oxidising materials. LiAlH₄ reacts violently with liquid water or high humidity, evolving hydrogen gas. The heat of reaction can also ignite the flammable solvents used and lead to explosion. ATMOSPHERIC OR REDUCED PRESSURES ONLY TO BE USED. REACTION TEMPERATURE SHOULD NOT EXCEED 60 C.

The full text files have not been included in this supplementary information except for the Assessment Outline for each. Full text files include details for the correct handling, storage, and disposal of chemicals relating to a specific hazard warning.

S.3.3.3 Local Laboratory Rules

The full Local Laboratory Rules for Laboratory 427 was converted to plain text and uploaded to SUSAN's Knowledge Bank. This document has not been included in this Supplementary Information, as it contains personal information: Staff List and Authorised Persons, Laboratory Floor-Plan And Evacuation Routes, Entry into Laboratories Following Fume Cupboard Shut Down, COSHH Operating Practices, Use of Fume Hoods, PPE, General Tidiness and Hygiene, Safety Equipment, General Laboratory Procedures, Pressure Vessels (excluding Autoclaves), Microwave Apparatus, Assembly of Glass Apparatus, Storage of Chemicals, Ultra-Violet Lamps and High Intensity Light Sources, Waste Disposal, Vacuum Techniques, Mercury, Emergency Contact Numbers, List of First Aiders, and Fire Wardens.

S.4 Testing

S.4.1 SAM

25 chemicals were chosen at random from the full chemical inventory (1026 items), and the location, CAS number, and stock code were requested from SAM. Full test results for both initial testing and personality matrix testing can be seen below:

Table 1 Initial testing performed on SAM with percentage of correct information provided for Location, CAS number, and Stock Code, as well as average accuracy scores and details for the format of data input into the Knowledge Bank.

Test	Data input format	Accuracy %			
		Location	CAS	Stock code	Average
1	Original/Raw data only	12	28	8	16
2	Condensed file	64	88	64	72
3	With line between each entry	36	68	24	43
4	With two lines between each	72	88	72	77
5	With multiple files (2 & 4)	76	88	76	80
6	Smaller tokens	28	60	24	37
7	Multiple files (2, 4) + exact match prompting	92	96	84	91

Prompts used for Test 7 and the below tests were:

“When I ask for a chemical provide me with the location, CAS number, and stock code. Only tell me information for exact matches, and not partial matches”

Two personality traits were modified as according to the main text. The tables below summarise scores for how these modifications altered rates of accuracy.

Table 2 Overall scores for accuracy of SAM when two personality aspects are changed; Meticulousness, and Guard Rail. Values obtained from tables 3, 4 and 5.

		Meticulousness:				
		100%	75%	50%	25%	0%
Guard Rail:	100%	79	71	77	79	85
	75%	95	92	93	77	76
	50%	56	77	81	80	79
	25%	76	81	87	76	92
	0%	88	89	80	80	81

Table 3 Location accuracy for SAM information retrieval upon modification of two personality traits.

		Meticulousness:				
		100%	75%	50%	25%	0%
Guard Rail:	100%	76	68	80	88	80
	75%	92	88	92	68	80
	50%	52	76	76	68	72
	25%	68	84	84	72	92
	0%	88	92	84	76	84

Table 4 CAS number accuracy for SAM information retrieval upon modification of two personality traits.

		Meticulousness:				
		100%	75%	50%	25%	0%
Guard Rail:	100%	84	76	84	72	96
	75%	100	100	100	96	80
	50%	72	80	92	96	92
	25%	92	84	92	80	92
	0%	92	92	84	84	84

Table 5 Stock Code accuracy for SAM information retrieval upon modification of two personality traits.

		Meticulousness:				
		100%	75%	50%	25%	0%
Guard Rail:	100%	76	68	66	76	80
	75%	92	88	88	68	68
	50%	44	76	76	76	72
	25%	68	76	84	76	92
	0%	84	84	72	80	80

S.4.1.1 Example conversations with SAM

Table 6 Several conversation snippets taken from conversations with SAM; text-based input and output unless otherwise stated.

Input question	Hello, my name is Mae, who are you?
ConvAI response	Hello Mae, I am Stock Controller. I am the AI responsible for keeping track of the inventory in Laboratory 427 at the UCL School of Pharmacy. I can help you locate the items you need in the lab.
Input question	I am looking for chloroethylamine hydrochloride.
ConvAI response	Chloroethylamine hydrochloride can be found in Cupboard 2 with the stock code 870-24-6 and the shelf code SH 226.
Input question	I am looking for a chemical with the CAS number 886-38-4 and the stock code SH627.
ConvAI response	Yes, we do have the chemical you are looking for. It is Diphenylcyclopropenone stored in CUPBOARD 6 with a CAS number of 886-38-4 and a stock code of SH 627.
Input question	Do we have tert-butylbromoacetate? Where can I find it?
ConvAI response	Yes, we do have tert-butylbromoacetate. It is stored in SMALL FRIDGE 1 and its CAS number is 5292-43-3. The shelf number is SH 324.
Input question	(Voice input) Where is indoline?
ConvAI response	Indoline, 98% can be found in Cupboard 8 with the stock code 496-15-1 and the shelf code SH 930.
Input question	Can you list all locations of aminopyridine?
ConvAI response	Yes, I can. 2-Aminopyridine is located in CUPBOARD 4 and has a shelf number of 504-29-0. 3-Aminopyridine is located in CUPBOARD 1, right side, with a shelf number of 462-08-8. Finally, 4-Aminopyridine is located in CUPBOARD 2 with a shelf number of 504-24-5.

S.4.2 SUSAN

S.4.2.1 Questions and Answers

General Health and Safety Questions and Answers

1. **What are the key principles of CoSHH in Lab427?**

Model Answer: The key principles of CoSHH (Control of Substances Hazardous to Health) in Lab427 are to assess the risks associated with hazardous substances, implement control measures to minimize exposure, provide appropriate training and information to staff, and regularly review and update safety process assessments.

Chat-GPT: The key principles of CoSHH in Lab427 include identifying hazardous substances, assessing the risks associated with them, and implementing control measures to protect the health and safety of lab personnel.D3

Untrained: The key principles of CoSHH (Control of Substances Hazardous to Health) in Lab427 are to assess the risks associated with hazardous substances, implement control measures to minimize exposure, provide appropriate training and information, and regularly review and update safety procedures.

Trained: The key principles of CoSHH (Control of Substances Hazardous to Health) in Lab427 are to assess the risks associated with hazardous substances, implement control measures to minimize exposure, provide appropriate training and information to staff, and regularly review and update risk assessments.

2. **Can you explain the difference between hazardous and non-hazardous chemicals?**

Model Answer: Hazardous chemicals are substances that have the potential to cause harm to human health or the environment. They may have properties such as toxicity, flammability, corrosiveness, or reactivity. Non-hazardous chemicals, on the other hand, do not possess these harmful properties and are considered safe to handle and use.

Chat-GPT: Hazardous chemicals are substances that can cause harm to human health or the environment. Non-hazardous chemicals do not pose such risks.

Untrained: Hazardous chemicals are substances that can cause harm to people or the environment. They can be toxic, corrosive, flammable, explosive, or have other hazardous properties. Non-hazardous chemicals are substances that do not pose a risk to people or the environment.

Trained: Hazardous chemicals are substances that have the potential to cause harm to human health or the environment. They may have properties such as toxicity, flammability, corrosiveness, or reactivity. Non-hazardous chemicals, on the other hand, do not possess these harmful properties and are considered safe to handle and use. It is important to properly identify and

handle hazardous chemicals to ensure the safety of individuals and the environment.

3. **What is the procedure for labeling chemical containers in the lab?**

Model Answer: Each compound is assigned a unique code, and the location, date of purchase, amount of material, recommended storage conditions and COSHH risk assessments are recorded in the central Chemical Inventory system.

Chat-GPT: Chemical containers in the lab should be labeled with the chemical's name, hazard symbol, appropriate hazard statements, and precautionary statements.

Untrained: The procedure for labeling chemical containers in the lab is to clearly label each container with the name of the chemical, the hazard symbol, and the date of opening. This information should be clearly visible and legible. Additionally, all containers should be stored in a secure location and away from sources of heat or ignition.

Trained: Chemical containers in the lab should be appropriately labeled with the inventory number. The primary container should also be sealed with nescofilm and inspected regularly for any damage or corrosion. If any containers have damaged packaging or labeling, they should be repackaged or disposed of safely. Additionally, it is recommended to use secondary containment when transporting containers between storage areas and working areas or between labs.

4. **How should chemical storage be organized to ensure safety?**

Model Answer: Chemical storage should be organized to ensure safety by keeping corrosive, flammable, and toxic materials separated from each other and from other materials. Store chemicals in a locked, ventilated area away from heat sources and direct sunlight. All samples and intermediates must be stored in a capped glass vial and labelled accordingly.

Chat-GPT: Chemical storage should be organized by segregating chemicals based on compatibility, using appropriate containers, and storing them in well-ventilated, secure areas away from incompatible substances.

Untrained: Chemical storage should be organized to ensure safety by storing chemicals in a secure location, away from sources of heat or ignition. Chemicals should also be stored according to their hazard class, with the most hazardous chemicals stored separately from less hazardous chemicals. Additionally, all containers should be clearly labeled with the name of the chemical, the hazard symbol, and the date of opening.

Trained: Chemical storage should be organized to ensure safety by keeping corrosive, flammable, and toxic materials separated from each other and from other materials. Store chemicals in a locked, ventilated area away from heat sources and direct sunlight. Regularly inspect stored containers and their labeling, and repackage or dispose of any materials with damaged or corroded packaging. It is also important to use secondary containment when

transporting primary containers from storage areas to the working area or between labs.

5. **Explain the importance of Material Safety Data Sheets (MSDS) in Lab427.**

Model Answer: Material Safety Data Sheets (MSDS) are important in Lab427 as they provide detailed information about the hazards, handling, storage, and emergency procedures for chemicals. They help lab personnel understand the potential risks associated with the chemicals they are working with and provide guidance on how to handle them safely.

Chat-GPT: Material Safety Data Sheets (MSDS) provide detailed information about the hazards, safe handling, and emergency procedures for chemicals used in the lab.

Untrained: Material Safety Data Sheets (MSDS) are important in Lab427 because they provide detailed information about the properties and hazards of a chemical, as well as the necessary safety precautions to take when working with the chemical. MSDS should be consulted before working with any hazardous chemical, and should be kept up to date with the most recent information.

Trained: Material Safety Data Sheets (MSDS) are important in Lab427 as they provide detailed information about the hazards, handling, storage, and emergency procedures for specific chemicals. They help lab personnel understand the potential risks associated with the chemicals they are working with and provide guidance on how to handle them safely. MSDS also contain information on first aid measures and spill cleanup procedures, ensuring that lab workers are prepared to respond to any incidents or accidents effectively.

6. **Describe the steps to conduct a risk assessment for a new chemical.**

Model Answer: A new specific COSHH assessment needs to be written, reviewed and approved before any practical work may take place if the use of a substance or substances is planned where none of the existing COSHH assessments cover the level of risk associated with this substance and no alternative substance can be used. The new COSHH process assessment must be prepared by the chemist intending to use the substance before it is purchased and the assessment must be reviewed and signed off by the Departmental Safety Advisor prior to substance use.

Chat-GPT: Conducting a risk assessment for a new chemical involves identifying its hazards, evaluating exposure routes, and implementing control measures to reduce risks.

Untrained: The steps to conduct a risk assessment for a new chemical include: 1) Identifying the hazards associated with the chemical; 2) Assessing the risks posed by the chemical; 3) Identifying the necessary control measures to reduce the risks; 4) Implementing the control measures; 5) Monitoring and reviewing the effectiveness of the control measures; and 6) Documenting the risk assessment.

Trained: To conduct a risk assessment for a new chemical in Lab427, follow these steps: 1. Identify the hazards: Determine the potential risks associated with the chemical, such as toxicity, flammability, reactivity, or environmental impact. 2. Assess exposure routes: Consider how lab personnel may come into contact with the chemical, whether through inhalation, skin contact, or ingestion. 3. Evaluate the level of exposure: Determine the quantity and duration of exposure to the chemical, taking into account factors like concentration, frequency of use, and ventilation. 4. Implement control measures: Identify and implement appropriate control measures to minimize exposure, such as using fume hoods, personal protective equipment (PPE), or engineering controls. 5. Provide training and information: Ensure that lab personnel are properly trained on the hazards of the chemical, its safe handling procedures, and emergency response protocols. 6. Review and update: Regularly review and update the risk assessment as new information becomes available or if there are any changes in the use or handling of the chemical. Remember, it is important to consult relevant safety guidelines, regulations, and the Material Safety Data Sheet (MSDS) for the specific chemical being assessed.

7. **How often should emergency eyewash and shower stations be inspected and maintained?**

Model Answer: Emergency eyewash and shower stations should be inspected and maintained weekly to ensure they are functional.

Chat-GPT: Emergency eyewash and shower stations should be inspected and maintained weekly to ensure they are functional and free from obstructions.

Untrained: Emergency eyewash and shower stations should be inspected and maintained at least once a month to ensure they are in proper working order. Additionally, they should be tested weekly to ensure they are functioning properly.

Trained: Emergency eyewash and shower stations should be inspected and maintained on a weekly basis to ensure they are accessible and in proper working condition. This regular inspection helps to identify any issues or malfunctions that may hinder their effectiveness during an emergency.

8. **What personal protective equipment (PPE) is required when working with corrosive chemicals?**

Model Answer: Safety Glasses and a clean laboratory coat are to be worn at all times in the laboratory, for the handling of chemicals and solvents, gloves are to be worn at all times with PPE 58 Purple Nitrile gloves worn which are intended for splash protection only.

Chat-GPT: When working with corrosive chemicals, lab personnel should wear appropriate PPE, including gloves, goggles, and lab coats.

Untrained: When working with corrosive chemicals, personal protective equipment (PPE) such as safety glasses, gloves, and a lab coat should be worn. Additionally, a face shield should be worn if there is a risk of splashing

or spraying of the chemical.

Trained: When working with corrosive chemicals in Lab427, it is necessary to wear the following personal protective equipment (PPE): 1. Safety goggles or a face shield: These protect the eyes and face from splashes or spills of corrosive chemicals. 2. Chemical-resistant gloves: Use gloves made of materials such as nitrile, neoprene, or PVC to protect the hands from direct contact with corrosive substances. 3. Lab coat or chemical-resistant apron: Wear a lab coat or apron made of chemical-resistant material to protect the body and clothing from chemical splashes or spills. 4. Closed-toe shoes: Wear closed-toe shoes, preferably made of chemical-resistant material, to protect the feet from potential spills or accidents. Remember to always consult the specific chemical's MSDS and follow the lab's standard operating procedures for handling corrosive substances.

9. **How should chemical spills be handled and reported in the lab?**

Model Answer: In the event of any spillage of material in the open lab, seek assistance from an experienced colleague. When necessary evacuate or cordon off the local area and contact the Site Emergency Services (x5826 or 0 for reception), informing them of the nature of the spillage. In the event of a spill of material in an extracted area, assistance from an experienced chemist is strongly recommended during cleaning. For spillages of non-water sensitive material within contained areas: - For solid materials, wherever possible damp down the spillage using water, so that the spread of dust is minimised. Use water -wet cloth or paper towels to wipe up spills and affected areas. Double-bag waste materials and dispose of in appropriate waste container. - Absorb liquid spills (<10 mL) onto cloths or paper towels. Larger quantities may be absorbed onto spillage absorption pads, which then can be bagged up. The affected area can then wiped with a water-wet cloth. Double-bag waste materials and dispose of in appropriate waste pails. For spillage of water-reactive materials avoid the use of water. Use an appropriate inert solvent as a cleaning agent if required.

Chat-GPT: Chemical spills should be immediately contained, neutralized, and cleaned up following lab-specific spill response procedures. All spills must be reported to the supervisor.

Untrained: Chemical spills in the lab should be handled immediately by containing the spill, if possible, and notifying the appropriate personnel. To report a chemical spill, follow the lab's specific procedures, which may involve contacting the lab supervisor or safety officer and completing an incident report.

Trained: All chemical spills should be promptly dealt with. In the event of a spillage, seek assistance from an experienced colleague. If the spillage is large or outside a contained or extracted area, evacuate the laboratory and contact the site Health and Safety service on the emergency telephone number. It is important to inform them about the nature of the spillage. The emergency telephone number out of working hours is 9-999.

10. **Can you provide an overview of the disposal process for hazardous waste in Lab427?**

Model Answer: Sharps should be disposed of in sharps bins located in each fumehood. Once full, seal and place in the locked shed in the Henrietta Mews store. Non-sharp contaminated waste, such as paper and gloves, should be collected in bags marked for incineration. Non-contaminated paper can be disposed of in the black sack lined bins for removal by the cleaning staff. Spent silica gel should be transferred to waste silica containers in the fume cupboards, securely packed in boxes, and stored in a suitable area for disposal. Liquids, including flammable and immiscible ones, should be collected separately in fumehoods or appropriate laboratory bins, and when full, emptied into the appropriate solvent drum. Waste solvents are collected in 10L drums, marked with the lab number and labeled chlorinated or non-chlorinated, and stored in the waste solvent store in the car park area.

Chat-GPT: Hazardous waste in Lab427 should be properly labeled, segregated, and disposed of following local regulations and guidelines.

Untrained: The disposal process for hazardous waste in Lab427 involves collecting the waste in a secure container, labeling the container with the name of the hazardous waste, and submitting the waste to the appropriate waste disposal facility. All hazardous waste should be disposed of in accordance with local, state, and federal regulations.

Trained: Hazardous waste in Lab427 should be disposed of following specific guidelines. Non-sharp contaminated waste, such as paper and gloves, should be collected in bags marked for incineration. Non-contaminated paper can be disposed of in the black sack lined bins for removal by the cleaning staff. Spent silica gel should be transferred to waste silica containers in the fume cupboards, securely packed in boxes, and stored in a suitable area for disposal. Liquids, including flammable and immiscible ones, should be collected separately in fumehoods or appropriate laboratory bins, and when full, emptied into the appropriate solvent drum. Waste solvents are collected in 10L drums, marked with the lab number and labeled chlorinated or non-chlorinated, and stored in the waste solvent store in the car park area.

11. **What is the purpose of the Chemical Hygiene Plan (CHP) in the lab?**

Model Answer: The CHP is a written program stating the policies, procedures and responsibilities that protect workers from the health hazards associated with the hazardous chemicals used in that particular workplace.

Chat-GPT: The Chemical Hygiene Plan (CHP) outlines safety procedures, practices, and policies for chemical handling in the lab.

Untrained: The purpose of the Chemical Hygiene Plan (CHP) in the lab is to provide guidance on the safe handling and storage of hazardous chemicals, as well as the necessary safety precautions to take when working with hazardous chemicals. The CHP outlines the responsibilities of the lab

personnel, the safety procedures to be followed, and the necessary personal protective equipment (PPE) to be worn when working with hazardous chemicals.

Trained: The purpose of the Chemical Hygiene Plan (CHP) in the lab is to ensure the safe handling, storage, and disposal of chemicals. It outlines the procedures and practices that need to be followed to minimize the risks associated with working with hazardous substances. The CHP also provides information on emergency procedures, personal protective equipment, and training requirements to promote a safe working environment.

12. **Explain the significance of ventilation systems in chemical labs.**

Model Answer: Ventilation systems play a crucial role in chemical labs as they help to control and minimize exposure to hazardous substances. They ensure the removal of harmful fumes, vapours, and dust particles from the lab environment, reducing the risk of inhalation or skin contact. Proper ventilation also helps maintain a safe and comfortable working atmosphere by regulating temperature, humidity, and air quality.

Chat-GPT: Ventilation systems in the lab help control chemical exposure by removing or diluting hazardous fumes and gases.

Untrained: Ventilation systems are important in chemical labs because they help to reduce the risk of exposure to hazardous chemicals. Proper ventilation systems help to reduce the concentration of hazardous chemicals in the air, as well as to remove any hazardous fumes or vapours. Additionally, ventilation systems help to reduce the risk of fire and explosion by removing any flammable vapours.

Trained: Ventilation systems play a crucial role in chemical labs as they help to control and minimize exposure to hazardous substances. They ensure the removal of harmful fumes, vapours, and dust particles from the lab environment, reducing the risk of inhalation or skin contact. Proper ventilation also helps maintain a safe and comfortable working atmosphere by regulating temperature, humidity, and air quality. It is essential to use fume hoods and other ventilation devices correctly to ensure the effectiveness of the system in protecting lab personnel.

13. **What should lab personnel do in case of a fire involving chemicals?**

Model Answer: In the event of a fire involving chemicals, lab personnel should follow these steps: 1. Sound the alarm: Immediately activate the fire alarm to alert others in the building. 2. Evacuate: Leave the area and evacuate the building using the designated escape routes. Do not use elevators. 3. Dial emergency number: Call the emergency number (x5826 or 0 for reception) from a safe location or instruct someone to do so. Provide information about the location and nature of the fire. 4. Do not attempt to tackle the fire: It is important not to try to extinguish the fire unless you have been trained to do so and have the appropriate equipment. Chemical fires can be highly hazardous.

Chat-GPT: In case of a fire involving chemicals, lab personnel should

activate the fire alarm, evacuate the area, and use appropriate fire extinguishers if safe to do so.

Untrained: In case of a fire involving chemicals, lab personnel should evacuate the area immediately and call the fire department. If the fire is small and can be safely extinguished, lab personnel should use the appropriate fire extinguisher and follow the safety guidelines outlined in the Chemical Hygiene Plan (CHP).

Trained: In the event of a fire involving chemicals, lab personnel should follow these steps: 1. Sound the alarm: Immediately activate the fire alarm to alert others in the building. 2. Evacuate: Leave the area and evacuate the building using the designated escape routes. Do not use elevators. 3. Dial emergency number: Call the emergency number (x5826 or 0 for reception) from a safe location or instruct someone to do so. Provide information about the location and nature of the fire. 4. Do not attempt to tackle the fire: It is important not to try to extinguish the fire unless you have been trained to do so and have the appropriate equipment. Chemical fires can be highly hazardous. 5. Follow instructions: Follow the instructions of emergency responders and evacuate to a safe assembly point outside the building. Remember, personal safety is the top priority in case of a fire.

14. **Describe the proper procedure for handling and disposing of sharps (e.g., needles, razor blades) in the lab.**

Model Answer: Disposal of sharps (syringe needles, scalpel blades, small broken glass items etc). Place these in a sharps bin. When this is full, seal and place in the locked shed in the Henrietta Mews store. UNDER NO CIRCUMSTANCES MUST SHARPS BE PLACED IN THE GENERAL WASTE.

Chat-GPT: Sharps should be disposed of in puncture-resistant containers following lab-specific protocols.

Untrained: The proper procedure for handling and disposing of sharps (e.g., needles, razor blades) in the lab is to place them in a puncture-resistant container that is clearly labeled as containing sharps. The container should be securely closed and disposed of according to local, state, and federal regulations. Additionally, all personnel should wear appropriate personal protective equipment (PPE) when handling sharps.

Trained: The proper procedure for handling and disposing of sharps in the lab is as follows: 1. Wear appropriate personal protective equipment (PPE): Put on gloves and any other necessary PPE before handling sharps to protect yourself from potential injuries. 2. Use a designated sharps container: Place used sharps, such as needles, razor blades, or broken glass, into a puncture-resistant sharps container. Do not overfill the container and ensure it is properly labeled. 3. Do not recap or bend needles: Never recap or bend needles by hand. Dispose of them directly into the sharps container. 4. Do not dispose of sharps in regular waste bins: Sharps should never be disposed of in regular waste bins or recycling containers. This helps prevent

injuries to waste handlers. 5. Do not dispose of sharps in sinks or drains: Sharps should never be disposed of in sinks or drains, as they can cause blockages and pose a risk to wastewater treatment systems. 6. Follow local regulations and guidelines: Familiarize yourself with the specific regulations and guidelines for sharps disposal in your lab or institution. Adhere to these guidelines to ensure proper handling and disposal. Remember, proper handling and disposal of sharps is essential to prevent injuries and maintain a safe working environment.

15. **How can exposure to fumes or gases be minimized during experiments?**

Model Answer: A key component of the Risk Assessment strategy in UCL School of Pharmacy is that the primary method of containment of hazards in chemistry laboratories is through the provision of vented fume cupboards or hoods. Each hood has an airflow monitor which triggers an alarm if the airflow drops below a pre-agreed manufacturer recommended level set to comply with H&S recommendations (0.5 m/s). Calibration of these airflow monitors is carried out annually. All processes involving substances categorised as hazardous to health should be conducted in a fume cupboard. Fume hood sashes should be lowered as far as possible at all times to maximise airflow and for the safety of all lab occupants.

Chat-GPT: Minimizing exposure to fumes or gases can be achieved through proper ventilation, the use of fume hoods, and wearing appropriate respiratory protection.

Untrained: Exposure to fumes or gases can be minimized during experiments by using proper ventilation systems, such as fume hoods or local exhaust ventilation systems. Additionally, personnel should wear appropriate personal protective equipment (PPE) when working with hazardous chemicals, and should follow the safety guidelines outlined in the Chemical Hygiene Plan (CHP).

Trained: To minimize exposure to fumes or gases during experiments, follow these steps: 1. Work in a well-ventilated area: Conduct experiments in a fume hood or a properly ventilated area to ensure the effective removal of fumes and gases. 2. Use appropriate containment measures: Utilize appropriate containment measures, such as sealed containers or closed systems, to prevent the release of fumes or gases into the lab environment. 3. Wear proper personal protective equipment (PPE): Always wear the recommended PPE, including gloves, safety glasses, and a lab coat, to protect yourself from potential exposure. 4. Handle chemicals safely: Follow proper handling procedures for chemicals, including using them in small quantities, avoiding unnecessary heating or mixing, and ensuring proper storage and labelling. 5. Monitor and control exposure levels: Use monitoring devices, such as gas detectors or air sampling, to assess and control the levels of fumes or gases in the lab. 6. Follow established protocols and guidelines: Adhere to established protocols and guidelines for working with

specific chemicals to minimize exposure risks. Remember, maintaining a safe working environment is crucial for minimizing exposure to fumes or gases during experiments.

16. **What measures should be taken to prevent cross-contamination in Lab427?**

Model Answer: To prevent cross-contamination in Lab427, ensure work surfaces are cleaned before and after use, appropriate personal protective equipment (PPE) is worn, chemicals are stored properly, and samples are labelled and handled correctly.

Chat-GPT: Cross-contamination can be prevented by segregating chemicals, using dedicated equipment, and following proper decontamination procedures.

Untrained: To prevent cross-contamination in Lab427, personnel should always wear appropriate personal protective equipment (PPE) when working with hazardous chemicals, and should follow the safety guidelines outlined in the Chemical Hygiene Plan (CHP). Additionally, all containers should be clearly labeled with the name of the chemical, the hazard symbol, and the date of opening. Finally, all chemicals should be stored according to their hazard class, with the most hazardous chemicals stored separately from less hazardous chemicals.

Trained: To prevent cross-contamination in Lab427, ensure separate equipment is used for different substances, work surfaces are cleaned before and after use, proper hand hygiene is practiced, appropriate personal protective equipment (PPE) is worn, chemicals are stored properly, and samples are labeled and handled correctly.

17. **Can you list some common signs of chemical exposure or poisoning?**

Model Answer: Common signs of chemical exposure or poisoning may include respiratory symptoms such as coughing, difficulty breathing, wheezing, or chest tightness. Skin reactions like irritation, redness, rash, or burns may also occur. Eye irritation can manifest as redness, watering, itching, or blurred vision. Digestive issues such as nausea, vomiting, abdominal pain, or diarrhea may be present. Neurological symptoms like headache, dizziness, confusion, weakness, or loss of consciousness can occur. Allergic reactions may manifest as itching, hives, swelling, or difficulty swallowing. Systemic effects such as fatigue, muscle weakness, organ dysfunction, or changes in blood pressure or heart rate may also be observed. It is important to seek immediate medical attention if any of these symptoms occur after chemical exposure.

Chat-GPT: Common signs of chemical exposure or poisoning include skin rashes, difficulty breathing, nausea, and dizziness.

Untrained: Common signs of chemical exposure or poisoning include skin irritation, eye irritation, coughing, difficulty breathing, dizziness, nausea, vomiting, headache, confusion, and fatigue. If any of these symptoms are present, personnel should seek medical attention immediately.

Trained: Common signs of chemical exposure or poisoning may include respiratory symptoms such as coughing, difficulty breathing, wheezing, or chest tightness. Skin reactions like irritation, redness, rash, or burns may also occur. Eye irritation can manifest as redness, watering, itching, or blurred vision. Digestive issues such as nausea, vomiting, abdominal pain, or diarrhoea may be present. Neurological symptoms like headache, dizziness, confusion, weakness, or loss of consciousness can occur. Allergic reactions may manifest as itching, hives, swelling, or difficulty swallowing. Systemic effects such as fatigue, muscle weakness, organ dysfunction, or changes in blood pressure or heart rate may also be observed. It is important to seek immediate medical attention if any of these symptoms occur after chemical exposure.

18. **Explain the importance of regular safety training for lab personnel.**

Model Answer: Regular safety training for lab personnel is important because it enhances awareness of potential hazards, promotes safe practices, mitigates risks, keeps personnel updated on safety regulations, and fosters a safety culture within the lab.

Chat-GPT: Regular safety training is essential for lab personnel to stay updated on safety protocols and practices.

Untrained: Regular safety training for lab personnel is important because it helps to ensure that personnel are aware of the safety procedures and protocols that should be followed when working with hazardous chemicals. Safety training also helps to ensure that personnel are familiar with the necessary personal protective equipment (PPE) to be worn when working with hazardous chemicals, as well as the proper disposal procedures for hazardous waste.

Trained: Regular safety training for lab personnel is important because it enhances awareness of potential hazards, promotes safe practices, mitigates risks, keeps personnel updated on safety regulations, and fosters a safety culture within the lab.

19. **What should be done to ensure the safety of pregnant or nursing lab workers?**

Model Answer: To ensure the safety of pregnant or nursing lab workers in Lab427, it is important to take the following measures: Conduct a risk assessment to identify potential hazards with reference to chemical MSDS. Provide appropriate and properly fitted personal protective equipment (PPE).

Chat-GPT: Pregnant or nursing lab workers should inform their supervisor and follow guidelines for minimizing chemical exposure during pregnancy or while breastfeeding.

Untrained: To ensure the safety of pregnant or nursing lab workers, they should be provided with additional safety training and should be given the necessary personal protective equipment (PPE) to protect them from hazardous chemicals. Additionally, they should be given the option to work with less hazardous chemicals or to work in a different area of the lab.

Finally, they should be monitored regularly to ensure that they are not exposed to any hazardous chemicals.

Trained: To ensure the safety of pregnant or nursing lab workers in Lab427, it is important to take the following measures: Conduct a risk assessment to identify potential hazards. Consult with healthcare professionals for advice and guidance. Maintain open communication with the worker. Consider modifying duties or providing alternative tasks. Provide appropriate and properly fitted personal protective equipment (PPE). Offer comprehensive training and education. Consider flexible work arrangements. Regularly monitor the worker's health and well-being.

20. **How often should emergency drills be conducted in the laboratory?**

Model Answer: Emergency drills in the laboratory should be conducted regularly as per Lab427 and UCL School of Pharmacy guidelines. It is important to ensure that all lab personnel are familiar with emergency procedures and can respond effectively in case of an actual emergency.

Chat-GPT: Emergency drills should be conducted periodically to ensure lab personnel are familiar with evacuation and safety procedures.

Untrained: Emergency drills should be conducted at least once a year in the laboratory to ensure that personnel are familiar with the safety procedures and protocols that should be followed in case of an emergency. Additionally, personnel should be trained on the proper use of emergency equipment, such as fire extinguishers and emergency eyewash and shower stations.

Trained: Emergency drills in the laboratory should be conducted regularly as per Lab427 guidelines. The frequency of drills may vary depending on factors such as the size of the lab, the number of personnel, and the specific hazards present. It is important to ensure that all lab personnel are familiar with emergency procedures and can respond effectively in case of an actual emergency.

21. **Describe the protocol for reporting accidents or near-miss incidents in Lab427.**

Model Answer: To report accidents or near-miss incidents in Lab427, immediately notify the laboratory supervisor or designated safety personnel by creating a RiskNET report. Provide a detailed account of the incident, including date, time, location, nature of the incident, any injuries or damage, and names of witnesses if applicable. Follow any additional reporting procedures specified by Lab427 and cooperate with investigations or follow-up actions. Timely reporting helps identify hazards and prevent future incidents.

Chat-GPT: Accidents or near-miss incidents should be reported to the supervisor or safety officer immediately.

Untrained: In Lab427, the protocol for reporting accidents or near-miss incidents is as follows: immediately notify the lab supervisor or safety officer, provide details of the incident, and complete an incident report form. It is important to document any injuries, damages, or potential hazards to ensure

proper investigation and prevention of future incidents.
Trained: To report accidents or near-miss incidents in Lab427, immediately notify the laboratory supervisor or designated safety personnel. Provide a detailed account of the incident, including date, time, location, nature of the incident, any injuries or damage, and names of witnesses if applicable. Follow any additional reporting procedures specified by Lab427 and cooperate with investigations or follow-up actions. Timely reporting helps identify hazards and prevent future incidents.

22. **Can you provide guidance on proper handwashing techniques for lab personnel?**

Model Answer: Lab personnel should wash their hands thoroughly with soap and water for at least 20 seconds. Pay attention to areas such as palms, backs of hands, between fingers, and under nails. Dry hands with a disposable towel or air dryer.

Chat-GPT: Proper handwashing techniques include using soap, water, and scrubbing for at least 20 seconds before rinsing and drying with disposable towels.

Untrained: Proper handwashing techniques for lab personnel include washing hands with soap and water for at least 20 seconds, scrubbing the hands and wrists, and drying hands with a clean towel or air dryer. Additionally, personnel should avoid touching their face, eyes, nose, and mouth with their hands, and should use hand sanitizer when soap and water are not available.

Trained: Lab personnel should wash their hands thoroughly with soap and water for at least 20 seconds. Pay attention to areas such as palms, backs of hands, between fingers, and under nails. Dry hands with a disposable towel or air dryer.

23. **Explain the procedure for verifying the compatibility of chemicals before mixing**

Model Answer: To verify the compatibility of chemicals before mixing, consult the Safety Data Sheets (SDS) or other reliable references for each chemical. Look for information on potential reactions, hazards, and incompatibilities. If there are any doubts or uncertainties, seek guidance from a qualified supervisor or safety professional.

Chat-GPT: Compatibility of chemicals should be verified using compatibility charts or databases before mixing them.

Untrained: The procedure for verifying the compatibility of chemicals before mixing involves consulting the Material Safety Data Sheets (MSDS) for each chemical to determine if they are compatible. Additionally, personnel should consult the Chemical Hygiene Plan (CHP) for guidance on the proper safety procedures to follow when mixing chemicals. Finally, personnel should wear the appropriate personal protective equipment (PPE) when mixing chemicals.

Trained: To verify the compatibility of chemicals before mixing, consult the

Safety Data Sheets (SDS) or other reliable references for each chemical. Look for information on potential reactions, hazards, and incompatibilities. If there are any doubts or uncertainties, seek guidance from a qualified supervisor or safety professional.

24. **What is the role of the Chemical Inventory Management System in Lab427?**

Model Answer: The Chemical Inventory Management System in Lab427 is used to track and manage the inventory of chemicals present in the laboratory. It helps in maintaining an accurate record of the chemicals, their quantities, locations, and associated hazards. This system aids in ensuring proper storage, handling, and disposal of chemicals, as well as facilitating efficient inventory management and regulatory compliance.

Chat-GPT: The Chemical Inventory Management System helps track and manage chemical inventory, ensuring proper storage and disposal.

Untrained: The role of the Chemical Inventory Management System in Lab427 is to track the quantity, location, and usage of all chemicals in the lab. This system helps to ensure that personnel are aware of the chemicals that are present in the lab, as well as the necessary safety precautions to take when working with hazardous chemicals. Additionally, the system helps to ensure that all chemicals are stored and disposed of according to local, state, and federal regulations.

Trained: The Chemical Inventory Management System in Lab427 is used to track and manage the inventory of chemicals present in the laboratory. It helps in maintaining an accurate record of the chemicals, their quantities, locations, and associated hazards. This system aids in ensuring proper storage, handling, and disposal of chemicals, as well as facilitating efficient inventory management and regulatory compliance.

25. **How should chemical waste be segregated before disposal?**

Model Answer: Flammable and immiscible liquids should be collected separately from other waste. Chlorinated and unchlorinated solvents should also be segregated. Additionally, solid and liquid waste should be separated. Proper segregation helps minimize the risk of reactions and ensures safe disposal.

Chat-GPT: Chemical waste should be segregated into categories such as hazardous, non-hazardous, and recyclable before disposal.

Untrained: Chemical waste should be segregated before disposal according to its hazard class. The most hazardous chemicals should be stored separately from less hazardous chemicals, and all containers should be clearly labeled with the name of the chemical, the hazard symbol, and the date of opening. Additionally, all chemical waste should be disposed of according to local, state, and federal regulations.

Trained: Chemical waste should be segregated before disposal based on their compatibility. Flammable and immiscible liquids should be collected separately from other waste. Chlorinated and unchlorinated solvents should

also be segregated. Additionally, solid and liquid waste should be separated. Proper segregation helps minimize the risk of reactions and ensures safe disposal.

26. **Describe the requirements for maintaining the safety shower and eyewash equipment.**

Model Answer: Safety shower and eyewash equipment should be tested weekly and maintained to ensure they function properly in case of emergencies. Ensure safety equipment is always accessible and that staff are fully trained in how to correctly use the equipment in the event of an emergency.

Chat-GPT: Safety shower and eyewash equipment should be tested regularly and maintained to ensure they function properly in case of emergencies.

Untrained: The requirements for maintaining the safety shower and eyewash equipment include inspecting and testing the equipment at least once a month to ensure it is in proper working order, and testing the equipment weekly to ensure it is functioning properly. Additionally, the equipment should be kept clean and free of any debris or obstructions, and the water supply should be checked regularly to ensure it is free of contaminants.

Trained: The safety shower and eyewash equipment should be maintained according to the following requirements: 1. Weekly Testing: The equipment should be tested weekly to ensure it is functioning properly. This includes activating the shower and eyewash to check for proper water flow and pressure. 2. Accessibility: The safety shower and eyewash should be easily accessible and free from any obstructions. They should be located within a 10-second reach from hazardous areas. 3. Clear Signage: Clear and visible signage should be placed to indicate the location of the safety shower and eyewash. 4. Training: Lab personnel should be trained on the proper use of the safety shower and eyewash equipment in case of an emergency. 5. Maintenance: Regular maintenance should be conducted to ensure the equipment is in good working condition. Any issues or malfunctions should be reported and repaired promptly. Remember, the safety shower and eyewash equipment are crucial for providing immediate first aid in case of chemical exposure, so it's important to keep them well-maintained and ready for use at all times.

27. **Can you explain the criteria for selecting appropriate PPE for specific tasks?**

Model Answer: When selecting appropriate personal protective equipment (PPE) for specific tasks, consider the nature of the hazards involved, such as chemical exposure, physical hazards, or biological risks. Consult safety data sheets, risk assessments, and relevant guidelines to determine the appropriate PPE for each task.

Chat-GPT: The selection of appropriate PPE depends on the specific

hazards associated with a task and may include gloves, goggles, lab coats, and respirators.

Untrained: The criteria for selecting appropriate PPE for specific tasks include considering the type of hazard, the duration of exposure, and the level of protection required. Additionally, personnel should consult the Material Safety Data Sheets (MSDS) for the chemicals they are working with to determine the necessary PPE. Finally, personnel should always wear the appropriate PPE when working with hazardous chemicals.

Trained: When selecting appropriate personal protective equipment (PPE) for specific tasks, consider the nature of the hazards involved, such as chemical exposure, physical hazards, or biological risks. Assess the level of protection required and choose PPE that effectively mitigates those hazards. Consult safety data sheets, risk assessments, and relevant guidelines to determine the appropriate PPE for each task.

28. **What precautions should be taken when working with highly flammable substances?**

Model Answer: When working with highly flammable substances, take precautions such as ensuring proper ventilation, using spark-proof equipment, and keeping ignition sources away. Store flammable substances in approved containers and limit quantities to minimize the risk. Refer to relevant COSHH Process Assessments.

Chat-GPT: When working with highly flammable substances, proper storage, handling, and ventilation measures must be in place to minimize the risk of fire.

Untrained: When working with highly flammable substances, personnel should always wear the appropriate personal protective equipment (PPE), such as safety glasses, gloves, and a lab coat. Additionally, a face shield should be worn if there is a risk of splashing or spraying of the chemical. The area should be well-ventilated, and all sources of heat or ignition should be kept away from the area. Finally, personnel should follow the safety guidelines outlined in the Chemical Hygiene Plan (CHP).

Trained: When working with highly flammable substances, take precautions such as ensuring proper ventilation, using spark-proof equipment, and keeping ignition sources away. Store flammable substances in approved containers and limit quantities to minimize the risk. Follow established procedures for handling, storage, and disposal to prevent accidents and fires.

29. **How should lab equipment be decontaminated after use?**

Model Answer: Lab equipment should be decontaminated after use by thoroughly cleaning it with appropriate decontamination agents, such as dilute sodium hydroxide solution. Ensure all surfaces and components are properly cleaned and rinsed to remove any traces of hazardous substances.

Chat-GPT: Lab equipment should be decontaminated after use using appropriate cleaning agents and procedures.

Untrained: Lab equipment should be decontaminated after use by following the appropriate safety procedures. This may include wiping down the equipment with a disinfectant solution, or autoclaving the equipment if necessary. Additionally, all personnel should wear appropriate personal protective equipment (PPE) when decontaminating lab equipment.

Trained: Lab equipment should be decontaminated after use by thoroughly cleaning it with appropriate decontamination agents, such as dilute sodium hydroxide solution. Ensure all surfaces and components are properly cleaned and rinsed to remove any traces of hazardous substances.

30. **What are the steps to follow when conducting a hazardous chemical inventory audit in Lab427?**

Model Answer: When conducting a hazardous chemical inventory audit in Lab427, follow these steps: 1. Review the existing inventory records and compare them with the actual stock of chemicals in the lab. 2. Physically inspect each chemical container to verify its identity, quantity, and condition. 3. Update the inventory records to reflect any discrepancies or changes in the stock. 4. Ensure proper labeling of all chemical containers with accurate information. 5. Identify and address any expired or unused chemicals for proper disposal. 6. Document the audit findings.

Chat-GPT: A hazardous chemical inventory audit involves verifying and documenting the presence, quantity, and storage of hazardous chemicals in the lab to ensure compliance with safety regulations.

Untrained: The steps to follow when conducting a hazardous chemical inventory audit in Lab427 include: 1) Identifying all hazardous chemicals in the lab; 2) Verifying the quantity, location, and usage of the hazardous chemicals; 3) Ensuring that all containers are properly labeled with the name of the chemical, the hazard symbol, and the date of opening; 4) Ensuring that all chemicals are stored according to their hazard class; 5) Ensuring that all chemicals are disposed of according to local, state, and federal regulations; and 6) Documenting the audit results.

Trained: When conducting a hazardous chemical inventory audit in Lab427, follow these steps: 1. Review the existing inventory records and compare them with the actual stock of chemicals in the lab. 2. Physically inspect each chemical container to verify its identity, quantity, and condition. 3. Update the inventory records to reflect any discrepancies or changes in the stock. 4. Ensure proper labeling of all chemical containers with accurate information. 5. Identify and address any expired or unused chemicals for proper disposal. 6. Document the audit findings and communicate any necessary actions to lab personnel and relevant stakeholders.

31. **What measures should be taken to ensure the safe transport of hazardous chemicals within the laboratory?**

Model Answer: To ensure the safe transport of hazardous chemicals within the laboratory, personnel should always wear the appropriate personal protective equipment (PPE) when handling the chemicals. Hazardous

chemicals transported outside of the laboratory must be carried in a secure secondary container.

Chat-GPT: To ensure the safe transport of hazardous chemicals within the laboratory, chemicals should be placed in secondary containment such as spill trays or tubs, and they should be moved using appropriate chemical-resistant containers. Care should be taken to avoid dropping or spilling chemicals during transport.

Untrained: To ensure the safe transport of hazardous chemicals within the laboratory, personnel should always wear the appropriate personal protective equipment (PPE) when handling the chemicals. Additionally, the chemicals should be stored in a secure container and labelled with the name of the chemical, the hazard symbol, and the date of opening. Finally, the chemicals should be transported in a well-ventilated area and away from sources of heat or ignition.

Trained: To ensure the safe transport of hazardous chemicals within the laboratory, use secondary containment, such as trays or carriers, to prevent spills or leaks. Handle chemicals with care, keeping them properly sealed and stable during transportation. Follow designated routes and avoid crowded areas to minimize the risk of accidents or exposure.

32. **Explain the protocol for conducting regular inspections of fume hoods in Lab427.**

Model Answer: The protocol for conducting regular inspections of fume hoods in Lab427 involves visually inspecting the hood for any signs of damage or wear, annually checking the airflow monitor to ensure it is within the recommended range, and verifying that the sash is functioning properly. Any issues or abnormalities should be reported and addressed promptly to maintain the effectiveness and safety of the fume hoods.

Chat-GPT: Regular inspections of fume hoods in Lab427 should include checking for proper airflow, inspecting the sash and baffle, ensuring the hood is clean, and verifying that alarms and airflow monitors are functional. Inspections should be conducted at least annually and documented.

Untrained: The protocol for conducting regular inspections of fume hoods in Lab427 includes inspecting the hoods for any signs of damage or wear, testing the hoods to ensure they are functioning properly, and verifying that the hoods are properly ventilated. Additionally, personnel should consult the Chemical Hygiene Plan (CHP) for guidance on the proper safety procedures to follow when working with hazardous chemicals.

Trained: The protocol for conducting regular inspections of fume hoods in Lab427 involves visually inspecting the hood for any signs of damage or wear, checking the airflow monitor to ensure it is within the recommended range, and verifying that the sash is functioning properly. Any issues or abnormalities should be reported and addressed promptly to maintain the effectiveness and safety of the fume hoods.

33. **What role does the Chemical Safety Data Sheet (CSDS) play in chemical management, and how is it different from an MSDS?**

Model Answer: The Chemical Safety Data Sheet (CSDS) plays a crucial role in chemical management by providing detailed information about the hazards, handling, storage, and emergency response procedures for a specific chemical. It is similar to an MSDS (Material Safety Data Sheet), but the CSDS is aligned with the Globally Harmonized System (GHS) of classification and labelling of chemicals, which provides a standardized format for communicating chemical hazards internationally.

Chat-GPT: The Chemical Safety Data Sheet (CSDS) is a document that provides information on the safe handling, storage, and disposal of chemicals used in the lab. It may include additional safety recommendations and precautions specific to the lab's procedures. It differs from an MSDS (Material Safety Data Sheet) in that it may include lab-specific guidance and local regulatory information.

Untrained: The Chemical Safety Data Sheet (CSDS) is a document that provides detailed information about the properties and hazards of a chemical, as well as the necessary safety precautions to take when working with the chemical. The CSDS is different from an MSDS in that it also includes information about the chemical's environmental and toxicological properties, as well as the necessary disposal procedures for the chemical. The CSDS should be consulted before working with any hazardous chemical, and should be kept up to date with the most recent information.

Trained: The Chemical Safety Data Sheet (CSDS) plays a crucial role in chemical management by providing detailed information about the hazards, handling, storage, and emergency response procedures for a specific chemical. It is similar to an MSDS (Material Safety Data Sheet), but the CSDS is aligned with the Globally Harmonized System (GHS) of classification and labeling of chemicals, which provides a standardized format for communicating chemical hazards internationally.

34. **Can you provide guidelines for the proper disposal of expired or unused chemicals in the laboratory?**

Model Answer: To properly dispose of expired or unused chemicals in the laboratory, follow these guidelines: 1. Review the chemical's Safety Data Sheet (SDS) for specific disposal instructions. 2. Segregate the chemicals based on their compatibility and hazardous properties. 3. Contact a licensed waste management company or the designated waste disposal facility for guidance on proper disposal methods. 4. Label the containers clearly as "Expired" or "Unused" to prevent accidental use.

Chat-GPT: Expired or unused chemicals in the laboratory should be properly labeled and segregated. They should be disposed of in accordance with local regulations and lab-specific procedures, which may involve contacting a hazardous waste disposal service or returning them to a chemical supplier.

Untrained: The guidelines for the proper disposal of expired or unused

chemicals in the laboratory include collecting the chemicals in a secure container, labeling the container with the name of the chemical, and submitting the waste to the appropriate waste disposal facility. All chemicals should be disposed of in accordance with local, state, and federal regulations. Additionally, personnel should consult the Material Safety Data Sheets (MSDS) for the chemicals they are disposing of to ensure that they are following the proper disposal procedures.

Trained: To properly dispose of expired or unused chemicals in the laboratory, follow these guidelines: 1. Review the chemical's Safety Data Sheet (SDS) for specific disposal instructions. 2. Segregate the chemicals based on their compatibility and hazardous properties. 3. Contact a licensed waste management company or the designated waste disposal facility for guidance on proper disposal methods. 4. Label the containers clearly as "Expired" or "Unused" to prevent accidental use. 5. Keep a record of the disposal process, including dates, quantities, and disposal methods, for documentation purposes.

35. **What documentation and records should be maintained to demonstrate compliance with CoSHH regulations in Lab427?**

Model Answer: To demonstrate compliance with CoSHH regulations in Lab427, maintain documentation and records such as COSHH process assessments, safety data sheets (SDS), training records, risk assessments, incident reports, and any relevant permits or licenses. These records should be readily accessible and kept up to date to ensure compliance with CoSHH regulations.

Chat-GPT: Documentation and records that should be maintained to demonstrate compliance with CoSHH regulations in Lab427 include: Chemical inventory lists, including quantities and locations. Training records for lab personnel including dates of training and topics covered. Inspection and maintenance records for safety equipment, such as eyewash stations and fume hoods. Incident reports for accidents, near-miss incidents, or chemical spills, along with their resolutions. Records of disposal of hazardous waste, including manifests and disposal certificates. Copies of safety policies, procedures, and the Chemical Hygiene Plan (CHP) for the laboratory.

Untrained: To demonstrate compliance with CoSHH regulations in Lab427, documentation and records should be maintained that include the CoSHH Process Assessments (or Risk Assessments) documents, the Chemical Hygiene Plan (CHP), the Material Safety Data Sheets (MSDS) for all hazardous chemicals, the Chemical Inventory Management System, and the incident report forms. Additionally, records should be kept of all safety training sessions and regular inspections of safety equipment.

Trained: To demonstrate compliance with CoSHH regulations in Lab427, maintain documentation and records such as COSHH process assessments, safety data sheets (SDS), training records, risk assessments, incident

reports, and any relevant permits or licenses. These records should be readily accessible and kept up to date to ensure compliance with CoSHH regulations.

Laboratory 427 Specific Questions and Answers

1. **How many COSSH process assessments are there in Lab427?**

Model Answer: In Lab427, there are a total of 18 COSHH process assessments.

Chat-GPT: In Lab427, there are typically multiple COSHH (Control of Substances Hazardous to Health) process assessments. The specific number can vary depending on the range of hazardous substances and processes used in the laboratory. It's advisable to consult with your lab's safety officer or supervisor for an exact count.

Untrained: There are currently three CoSSH Process Assessments (or Risk Assessments) documents in Lab427. These documents provide detailed information about the safety procedures and protocols that should be followed when working with hazardous chemicals. Additionally, they provide guidance on the necessary personal protective equipment (PPE) to be worn when working with hazardous chemicals, as well as the proper disposal procedures for hazardous waste.

Trained: In Lab427, there are a total of 18 COSHH process assessments.

2. **Can you list all COSSH documents?**

Model Answer: The COSHH process assessments in Lab427 are: CG1: General Code of Practice, CG2: Very Toxic, Carcinogenic, Mutagenic or Sensitizing, CG3: Pyrophoric Liquids, CG4: Water Sensitive Reagents, CG5: Oxidants, CG6: Potentially Explosive Materials, CG7: Pressurized Gases, CG8: Reactive Metal Hydrides, CG9: Hydrogenation, CG10: Ethers, CS1: Azides, CS2: Cyanides, CS3: Ozone, CS4: Phosgene, CS5: Phenols, CS6: TFA/TFAA, CS7: POCI₃, CS8: LiAlH₄.

Chat-GPT: The list of COSHH documents can be extensive and includes Material Safety Data Sheets (MSDS), Chemical Safety Data Sheets (CSDS), risk assessments, safety protocols, and the Chemical Hygiene Plan (CHP), among others. It's essential to maintain a comprehensive repository of these documents for reference and compliance purposes.

Untrained: The CoSSH Process Assessments (or Risk Assessments) documents in Lab427 include: 1) Chemical Hygiene Plan (CHP); 2) Material Safety Data Sheets (MSDS); 3) Chemical Inventory Management System; 4) Incident Report Forms; and 5) Safety Training Records. Additionally, personnel should consult the local, state, and federal regulations for guidance on the proper disposal of hazardous waste.

Trained: I can provide you with a summary of the COSHH process assessments in Lab427: CG1: General Code of Practice, CG2: Very Toxic, Carcinogenic, Mutagenic or Sensitizing, CG3: Pyrophoric Liquids, CG4: Water Sensitive Reagents, CG5: Oxidants, CG6: Potentially Explosive Materials,

CG7: Pressurized Gases, CG8: Reactive Metal Hydrides, CG9: Hydrogenation, CG10: Ethers, CS1: Azides, CS2: Cyanides, CS3: Ozone, CS4: Phosgene, CS5: Phenols, CS6: TFA/TFAA, CS7: POCl₃, CS8: LiAlH₄. These are the COSHH process assessments relevant to Lab427.

3. **Can you tell me more about CG4?**

Model Answer: CG4 is the COSHH process assessment for Water Sensitive Reagents in Lab427. Water sensitive reagents are substances that react violently or release toxic gases upon contact with water or moisture. This assessment provides guidelines and precautions for handling, storage, and disposal of water sensitive reagents to minimize the risk of accidents or hazardous reactions. It includes information on the specific hazards associated with these reagents and recommended control measures to ensure safe handling and use in the laboratory.

Chat-GPT: CG4, or Control Guidance Note 4, is a specific document that provides detailed guidance on the safe handling, storage, and disposal of hazardous substances or processes in Lab427. It outlines control measures and best practices to mitigate risks associated with these substances or processes. You should consult CG4 for specific information related to your work.

Untrained: CG4 is a document from the CoSSH Process Assessments (or Risk Assessments) documents in Lab427. It outlines the safety procedures and protocols that should be followed when working with hazardous chemicals, as well as the necessary personal protective equipment (PPE) to be worn when working with hazardous chemicals. Additionally, it provides guidance on the proper disposal procedures for hazardous waste.

Trained: CG4 is the COSHH process assessment for Water Sensitive Reagents in Lab427. Water sensitive reagents are substances that react violently or release toxic gases upon contact with water or moisture. This assessment provides guidelines and precautions for handling, storage, and disposal of water sensitive reagents to minimize the risk of accidents or hazardous reactions. It includes information on the specific hazards associated with these reagents and recommended control measures to ensure safe handling and use in the laboratory.

4. **I need to use some TFA in my experiment. Which risk assessment should I refer to and can you summarise it.**

Model Answer: You should refer to the CS6 risk assessment for the use of TFA (Trifluoroacetic acid) in Lab427. The CS6 risk assessment covers the handling and use of TFA in the laboratory.

Chat-GPT: When working with Trifluoroacetic acid (TFA), you should refer to the risk assessment associated with this chemical. The risk assessment will provide information on the hazards, safe handling procedures, required personal protective equipment (PPE), and emergency measures. Always follow the guidance outlined in the TFA risk assessment to ensure safety.

Untrained: For your experiment involving TFA, you should refer to the

CoSSH Process Assessments (or Risk Assessments) document CG4. This document outlines the safety procedures and protocols that should be followed when working with hazardous chemicals, as well as the necessary personal protective equipment (PPE) to be worn when working with hazardous chemicals. Additionally, it provides guidance on the proper disposal procedures for hazardous waste. Specifically, when working with TFA, personnel should wear safety glasses, gloves, and a lab coat, and should ensure that the area is well-ventilated. Additionally, personnel should avoid contact with skin, eyes, and clothing, and should avoid breathing in the fumes or vapors. Finally, all containers should be labeled with the name of the chemical, the hazard symbol, and the date of opening.

Trained: You should refer to the CS6 risk assessment for the use of TFA (Trifluoroacetic acid) in Lab427. The CS6 risk assessment covers the handling and use of TFA in the laboratory. TFA is classified as harmful by inhalation and causes severe burns. It is also harmful to aquatic organisms and may cause long-term adverse effects in the aquatic environment. The risk assessment emphasizes the importance of using a suitable protective full-face shield when working with TFA.

5. **Can you tell me more about Lab 427?**

Model Answer: Lab 427 is a chemical laboratory located in the UCL School of Pharmacy, managed by Dr Stephen Hilton.

Chat-GPT: Lab 427 is a specific laboratory facility that may have unique characteristics and processes. To learn more about Lab 427, including its layout, specific research activities, and safety protocols, you should contact the lab manager or safety officer responsible for that facility.

Untrained: Lab 427 is a designated laboratory space at the UCL School of Pharmacy. It is specifically designed for scientific research and experimentation. The lab is equipped with state-of-the-art equipment and facilities to support various research projects related to pharmaceutical sciences. It is important to follow the health and safety guidelines in Lab 427 to ensure a safe working environment for everyone.

Trained: Lab 427 is a specific laboratory located at the UCL School of Pharmacy. It is a designated space where various scientific experiments and research activities take place. Lab 427 follows specific health and safety guidelines, including CoSHH (Control of Substances Hazardous to Health) regulations, to ensure the safety of personnel and the proper handling of chemicals and equipment. The lab is equipped with necessary facilities and equipment to support scientific work, and it is managed by a laboratory manager who oversees the operations and safety protocols.

6. **What does CG1 cover?**

Model Answer: CG1 is the COSHH process assessment that covers the General Code of Practice in Lab427. It provides general guidelines and best practices for handling hazardous substances and managing risks in the laboratory. CG1 includes information on the proper storage, handling, and

disposal of chemicals, as well as guidance on personal protective equipment (PPE), emergency procedures, and training requirements. It serves as a foundation for maintaining a safe working environment and complying with health and safety regulations in Lab427.

Chat-GPT: CG1 typically covers general safety procedures and guidelines in the laboratory. It may include information on laboratory entry and exit, PPE requirements, basic chemical handling, and emergency procedures.

Untrained: CG1 is a document from the CoSSH Process Assessments (or Risk Assessments) documents in Lab427. It covers the safety procedures and protocols that should be followed when working with hazardous chemicals, as well as the necessary personal protective equipment (PPE) to be worn when working with hazardous chemicals. Additionally, it provides guidance on the proper disposal procedures for hazardous waste.

Trained: CG1 is the COSHH process assessment that covers the General Code of Practice in Lab427. It provides general guidelines and best practices for handling hazardous substances and managing risks in the laboratory. CG1 includes information on the proper storage, handling, and disposal of chemicals, as well as guidance on personal protective equipment (PPE), emergency procedures, and training requirements. It serves as a foundation for maintaining a safe working environment and complying with health and safety regulations in Lab427.

7. **What does CS5 cover?**

Model Answer: CS5 is the COSHH process assessment that covers the handling and use of Phenols in Lab427. Phenols are a class of chemical compounds that can be hazardous to health and the environment. The CS5 assessment provides specific guidelines and precautions for working with phenols, including information on their potential health effects, proper storage, handling, and disposal methods. It also outlines the necessary control measures, such as the use of appropriate personal protective equipment (PPE) and ventilation, to minimize the risks associated with phenols in the laboratory.

Chat-GPT: CS5 likely covers specific safety procedures and guidelines for handling substances or processes categorized under CS5. The exact contents of CS5 will depend on the hazardous nature of the substances or processes it addresses.

Untrained: CS5 is a document from the CoSSH Process Assessments (or Risk Assessments) documents in Lab427. It covers the safety procedures and protocols that should be followed when working with hazardous chemicals, as well as the necessary personal protective equipment (PPE) to be worn when working with hazardous chemicals. Additionally, it provides guidance on the proper disposal procedures for hazardous waste.

Trained: CS5 is the COSHH process assessment that covers the handling and use of Phenols in Lab427. Phenols are a class of chemical compounds that can be hazardous to health and the environment. The CS5 assessment

provides specific guidelines and precautions for working with phenols, including information on their potential health effects, proper storage, handling, and disposal methods. It also outlines the necessary control measures, such as the use of appropriate personal protective equipment (PPE) and ventilation, to minimize the risks associated with phenols in the laboratory.

a. **What should I be aware of when working with phenols?**

Model Answer: When working with phenols, there are several important considerations to be aware of: 1. Skin Absorption: Phenols can be rapidly absorbed through the skin, so it is crucial to take precautions to prevent direct contact. Wear appropriate personal protective equipment (PPE), such as gloves and lab coats, to minimize skin exposure. 2. Inhalation Hazards: Phenols can release toxic vapors when heated or in contact with strong acids. Ensure proper ventilation in the laboratory and use fume hoods when working with volatile phenols. 3. Corrosive Properties: Phenols can cause burns and tissue damage upon contact. Handle them with care and avoid splashes or spills. In case of contact, immediately rinse the affected area with water and seek medical attention if necessary. 4. Storage and Labeling: Store phenols in appropriate containers, properly labeled with their contents and hazards. Keep them in a designated area away from incompatible substances to prevent reactions. 5. Disposal: Follow proper disposal procedures for phenols as outlined in the COSHH process assessment and local regulations. Do not dispose of phenols down the drain or in regular waste bins. Always refer to the specific COSHH process assessment for phenols (CS5) and the Safety Data Sheet (SDS) for your chemical.

Chat-GPT: When working with phenols, it's essential to be aware of their potential toxicity, flammability, and corrosive properties. Proper personal protective equipment (PPE), such as gloves and lab coats, should be worn. Additionally, phenols should be handled in a well-ventilated area or within a chemical fume hood to minimize inhalation exposure.

Untrained: When working with phenols, personnel should always wear the appropriate personal protective equipment (PPE), such as safety glasses, gloves, and a lab coat. Additionally, a face shield should be worn if there is a risk of splashing or spraying of the chemical. The area should be well-ventilated, and all sources of heat or ignition should be kept away from the area. Finally, personnel should follow the safety guidelines outlined in the Chemical Hygiene Plan (CHP).

Trained: When working with phenols, there are several important considerations to be aware of: 1. Skin Absorption: Phenols can be rapidly absorbed through the skin, so it is crucial to take precautions to prevent direct contact. Wear appropriate personal protective equipment

(PPE), such as gloves and lab coats, to minimize skin exposure. 2. Inhalation Hazards: Phenols can release toxic vapors when heated or in contact with strong acids. Ensure proper ventilation in the laboratory and use fume hoods when working with volatile phenols. 3. Corrosive Properties: Phenols can cause burns and tissue damage upon contact. Handle them with care and avoid splashes or spills. In case of contact, immediately rinse the affected area with water and seek medical attention if necessary. 4. Storage and Labeling: Store phenols in appropriate containers, properly labeled with their contents and hazards. Keep them in a designated area away from incompatible substances to prevent reactions. 5. Disposal: Follow proper disposal procedures for phenols as outlined in the COSHH process assessment and local regulations. Do not dispose of phenols down the drain or in regular waste bins. Always refer to the specific COSHH process assessment for phenols (CS5) and the Safety Data Sheet (SDS) for your chemical.

8. **What do I do in the event of a fire?**

Model Answer: In the event of a fire, immediately sound the alarm and dial the emergency number (x5826 or 0 for reception) from a safe location or instruct someone to do so. Evacuate the immediate area and only attempt to tackle the fire if it is small and you feel competent to do so, and only if you are not putting yourself or others at risk.

Chat-GPT: In the event of a fire in the laboratory, follow the lab's established emergency procedures. Typically, this involves activating the fire alarm, evacuating the lab, and using the nearest fire extinguisher if safe to do so. Never compromise your safety during a fire emergency, and always evacuate the building if instructed.

Untrained: In the event of a fire, personnel should evacuate the area immediately and call the fire department. If the fire is small and can be safely extinguished, lab personnel should use the appropriate fire extinguisher and follow the safety guidelines outlined in the Chemical Hygiene Plan (CHP).

Trained: In the event of a fire, immediately sound the alarm and dial the emergency number (x5826 or 0 for reception) from a safe location or instruct someone to do so. Evacuate the immediate area and only attempt to tackle the fire if it is small and you feel competent to do so, and only if you are not putting yourself or others at risk.

9. **What should I do if I spill some phosgene on my labcoat?**

Model Answer: If you spill phosgene on your lab coat, take off immediately all contaminated clothing, and wash immediately with plenty of water - seek medical advice immediately.

Chat-GPT: If you spill some phosgene on your lab coat, immediately remove the contaminated lab coat, and place it in a designated hazardous waste container. Rinse the affected area of your skin with copious amounts of water. Seek medical attention promptly if necessary.

Untrained: If you spill phosgene on your lab coat in Lab 427, it is crucial to prioritize your safety. Immediately remove the contaminated lab coat and place it in a designated hazardous waste container. Rinse the affected area of your skin with copious amounts of water and seek medical attention promptly. It is essential to report the incident to the lab supervisor or safety officer for further guidance and documentation.

Trained: If you spill phosgene on your lab coat, remove the contaminated lab coat immediately and place it in a designated hazardous waste container. Rinse the affected area of your skin with copious amounts of water for at least 15 minutes and seek medical attention immediately.

a. **What if it goes in my eyes?**

Model Answer: If there is contact with eyes irrigate using the eyewash station for at least 20 minutes and seek medical advice immediately.

Chat-GPT: If phosgene comes into contact with your eyes, immediately flush your eyes with an eyewash station for at least 15 minutes and seek immediate medical attention. Notify your supervisor or lab safety officer of the incident.

Untrained: If phosgene gets into your eyes in Lab 427, it is a medical emergency. Immediately rinse your eyes with water for at least 15 minutes while keeping your eyelids open. Seek immediate medical attention and inform the lab supervisor or safety officer about the incident. Remember, quick action is crucial in minimizing potential harm and ensuring proper treatment.

Trained: If phosgene gets in your eyes, immediately rinse your eyes using the eyewash station for at least 20 minutes and seek immediate medical attention. Do not delay seeking medical help, as phosgene exposure to the eyes can cause serious damage.

10. **Which chemicals do I need to avoid coming in to contact with if I am pregnant?**

Model Answer: If you are pregnant, you should avoid coming into contact with any hazardous chemicals. Additionally, you should consult the Material Safety Data Sheets (MSDS) for the chemicals you are working with to determine the necessary safety precautions to take when working with the chemicals.

Chat-GPT: If you are pregnant, you should avoid coming into contact with teratogenic and reproductive hazards. Consult the lab's safety documentation or your supervisor for a list of chemicals to avoid. Common substances to avoid include teratogenic solvents and certain heavy metals.

Untrained: If you are pregnant, you should avoid coming into contact with any hazardous chemicals. Additionally, you should consult the Material Safety Data Sheets (MSDS) for the chemicals you are working with to determine the necessary safety precautions to take when working with the chemicals. Finally, you should always wear the appropriate personal protective equipment (PPE) when working with hazardous chemicals.

Trained: If you are pregnant, it is important to avoid coming into contact with chemicals that are known to be teratogenic or harmful to the unborn child. Some examples include lead, mercury, certain solvents (such as benzene and toluene), certain pesticides, and certain chemotherapy drugs. It is best to consult with your supervisor or the laboratory's safety officer for a comprehensive list of chemicals to avoid during pregnancy.

11. **Do we have emergency showers?**

Model Answer: An emergency shower is located in the synthetic chemistry laboratory 427 near the entrance, and outside laboratory 436.

Chat-GPT: Yes, emergency showers are typically available in chemical laboratories like Lab427. They are used for rinsing off hazardous chemicals that may come into contact with the skin or clothing.

Untrained: Yes, Lab427 is equipped with emergency showers and eyewash stations. These should be tested weekly to ensure they are functioning properly, and personnel should be trained on the proper use of the emergency equipment. Additionally, personnel should always wear the appropriate personal protective equipment (PPE) when working with hazardous chemicals.

Trained: The emergency shower is located in Laboratory 427, near the entrance of the laboratory. It is important to familiarize yourself with the specific location of the emergency shower in your laboratory for quick access in case of an emergency.

12. **Can you give me specific safety information about working with tert-butyl lithium?**

Model Answer: When working with tert-butyl lithium, use air-free techniques, appropriate PPE (gloves, safety glasses, and lab coat), and away from potential ignition causes. Always consult the chemical's MSDS or CSDS for detailed safety instructions.

Chat-GPT: Working with tert-butyl lithium is highly hazardous and should only be performed by trained personnel in a controlled environment. Specific safety information includes the use of air-free techniques, appropriate PPE (including fire-resistant lab coats and face shields), and a designated area for its use. Always consult the chemical's MSDS or CSDS for detailed safety instructions.

Untrained: When working with tert-butyl lithium, personnel should always wear the appropriate personal protective equipment (PPE), such as safety glasses, gloves, and a lab coat. Additionally, a face shield should be worn if there is a risk of splashing or spraying of the chemical. The area should be well-ventilated, and all sources of heat or ignition should be kept away from the area. Finally, personnel should follow the safety guidelines outlined in the Material Safety Data Sheet (MSDS) for tert-butyl lithium.

Trained: When working with tert-butyl lithium, ensure good ventilation, wear appropriate PPE (gloves, safety glasses, lab coat), store it in a cool, dry place away from heat or ignition sources, use caution during handling to prevent

contact with air or moisture, and evacuate and seek help in case of spills or fires.

a. **How would I dispose of tert-butyl lithium?**

Model Answer: Disposing of tert-butyl lithium should be done under the guidance of hazardous waste disposal experts, as it reacts violently with air and water. It should be quenched with an appropriate reagent and then disposed of as hazardous waste following local regulations and lab-specific procedures.

Chat-GPT: Disposing of tert-butyl lithium should be done under the guidance of hazardous waste disposal experts, as it reacts violently with air and water. It should be quenched with an appropriate reagent and then disposed of as hazardous waste following local regulations and lab-specific procedures.

Untrained: Tert-butyl lithium should be disposed of according to local, state, and federal regulations. Additionally, personnel should consult the Material Safety Data Sheet (MSDS) for tert-butyl lithium to ensure that they are following the proper disposal procedures. Finally, all containers should be labeled with the name of the chemical, the hazard symbol, and the date of opening.

Trained: The disposal of tert-butyl lithium should be carried out under the guidance of the Departmental Safety Officer or a qualified professional. Due to its reactivity and potential hazards, it is important to follow proper disposal procedures. Typically, tert-butyl lithium is destroyed by reaction with a suitable quenching agent, such as isopropanol or ethanol, under inert conditions. It is crucial to consult the specific CoSSH Process Assessment or seek guidance from the appropriate authorities for safe and proper disposal methods in your laboratory.

13. **Can you look up the SDS for sodium azide?**

Model Answer: I can look up the SDS for sodium azide, which provides important safety information, handling instructions, and emergency procedures specific to sodium azide.

Chat-GPT: To access the Safety Data Sheet (SDS) for sodium azide, consult the laboratory's SDS database or contact the lab's safety officer or chemical inventory manager.

Untrained: Yes, I can look up the Material Safety Data Sheet (MSDS) for sodium azide. The MSDS provides detailed information about the properties and hazards of sodium azide, as well as the necessary safety precautions to take when working with the chemical. Additionally, it includes information about the chemical's environmental and toxicological properties, as well as the necessary disposal procedures for the chemical.

Trained: I apologize, but as Safety Susan, I do not have the capability to look up specific Safety Data Sheets (SDS). However, you can typically find the SDS for sodium azide by searching online on reputable chemical supplier

websites or by contacting the manufacturer directly. The SDS will provide important safety information, handling instructions, and emergency procedures specific to sodium azide.

a. **What should I do if I spill sodium azide?**

Model Answer: In the event of a spill of material in an extracted area, assistance from an experienced chemist is strongly recommended during cleaning. All spillages must be dealt with promptly. If spillage can be collected, treat by the work up planned for the reaction. Ceric ammonium nitrate can also be used to render spillages less harmful. Use 9 g ceric ammonium nitrate in water (170 mL) per 1 g azide; cover spillage with solution; when nitrogen evolution has ceased (preferably leave overnight) then dispose of solution to sink with copious water. Paper towel etc. used to control spillage should be rinsed well with water before disposal (contaminated waste bin). Seal and dispose of sack immediately. For spillage outside a fume cupboard, evacuate the immediate area and seek assistance (your supervisor or Health and Safety Advisor).

Chat-GPT: In the event of a sodium azide spill, immediately alert others, evacuate the area, and follow the lab's spill response procedures. Sodium azide is highly toxic and should be handled with extreme caution. It may require specialized cleanup procedures.

Untrained: If you spill sodium azide in Lab 427, it is important to handle the situation with caution. Sodium azide is a toxic substance that can release toxic gases when in contact with certain chemicals. First, alert others in the lab and evacuate the area if necessary. Then, carefully contain the spill by using appropriate absorbent materials and follow the lab's specific procedures for cleaning up hazardous spills. It is crucial to wear appropriate personal protective equipment (PPE) and dispose of the contaminated materials properly. Finally, report the incident to the lab supervisor or safety officer for further guidance and documentation.

Trained: If you spill sodium azide, immediately evacuate if necessary, put on appropriate PPE, contain the spill if possible, avoid creating dust or inhaling fumes, clean up the spill using absorbent material, thoroughly clean the area, dispose of contaminated materials properly, and report the spill to your supervisor or safety officer.

14. **Where should I store calcium chloride?**

Model Answer: Calcium chloride should be stored in a cool, dry place away from incompatible substances such as strong acids or organic materials. It should be kept in a labelled container and properly sealed to prevent moisture absorption.

Chat-GPT: Calcium chloride should be stored in a cool, dry place away from incompatible substances such as strong acids or organic materials. It should be kept in a labelled container and properly sealed to prevent moisture

absorption.

Untrained: Calcium chloride should be stored in a secure container and labelled with the name of the chemical, the hazard symbol, and the date of opening. Additionally, it should be stored according to its hazard class, and personnel should consult the Material Safety Data Sheet (MSDS) for the chemical to ensure that they are following the proper safety procedures. Finally, all chemicals should be disposed of in accordance with local, state, and federal regulations.

Trained: Calcium chloride should be stored in a cool, dry place, away from sources of heat or ignition. It should be kept in a tightly sealed container and stored separately from incompatible substances. Additionally, it is important to label the container properly and ensure that it is stored in a designated area or cabinet for chemicals.

15. Who should I speak to if I have more questions regarding health and safety in Lab427?

Model Answer: For any further questions regarding health and safety in Lab427, you should direct your inquiries to Dr. Stephen Hilton, the Lab427 manager.

Chat-GPT: If you have more questions regarding health and safety in Lab427, you should contact the lab's safety officer or manager. They will provide you with guidance, training, and answers to specific safety-related inquiries to ensure a safe working environment.

Untrained: If you have more questions regarding health and safety in Lab427, I recommend speaking to the lab supervisor or safety officer. They are knowledgeable about the specific guidelines and protocols in place and can provide you with the necessary information and guidance to ensure a safe working environment. Don't hesitate to reach out to them for any concerns or queries you may have.

Trained: For any further questions regarding health and safety in Lab427, you should direct your inquiries to Dr. Stephen Hilton, the Lab427 manager. He is the expert in the local rules and practices of the laboratory and can provide you with specific information related to the CoSSH Process Assessments (or Risk Assessments) and other health and safety guidelines.

S.4.2.2 Human Evaluation

Table 7 Likert scores used for Human Evaluation of Accuracy and Clarity of SUSAN's responses

Likert Scale: Accuracy

1	Completely incorrect
2	Correct, missing significant information
3	Correct, missing some information
4	Correct with reference to external sources
5	Correct with reference to internal sources

Likert Scale: Clarity

1	Unclear, poorly structured, non-concise
2	Answer is relatively concise and conversational, out-of-scope information, incomplete response
3	Clear, easily understood, non-repetitive and concise

Table 8 All Human Evaluation scores for 54 questions asked to SUSAN, rated for accuracy and clarity, and compared to Chat-GPT and an Untrained ConvAI.

	Question	ChatGPT		Untrained ConvAI		Trained ConvAI	
		Accurac y - Likert	Clarity - Likert	Accurac y - Likert	Clarity - Likert	Accurac y - Likert	Clarity - Likert
General CoSSH	1	3	3	5	3	5	3
	2	3	2	5	3	5	3
	3	2	3	3	2	3	2
	4	3	3	3	2	4	2
	5	5	3	5	3	5	2
	6	3	3	4	3	3	1
	7	5	3	5	3	5	3
	8	4	3	4	3	4	2
	9	3	3	3	2	3	2
	10	2	3	3	2	5	3
	11	4	3	5	3	4	3
	12	3	3	5	3	5	3
	13	3	3	4	3	5	3
	14	2	3	3	2	3	3
	15	4	3	4	3	4	1
	16	4	3	4	3	5	3
	17	4	3	4	3	5	3
	18	5	3	5	3	5	3
	19	4	3	3	2	5	2
	20	3	3	1	2	5	2

	21	2	3	5	3	5	3
	22	5	3	5	2	5	3
	23	4	3	4	2	5	3
	24	3	3	4	2	5	3
	25	3	3	1	2	5	3
	26	5	3	3	2	5	1
	27	3	3	5	3	5	3
	28	3	3	3	3	5	3
	29	4	3	3	2	5	3
	30	2	3	4	2	5	3
	31	4	3	3	3	5	3
	32	5	3	4	2	5	3
	33	5	3	1	2	5	3
	34	4	3	4	3	5	3
	35	4	3	5	3	5	3
Laboratory 47 specific	36	1	3	1	3	5	3
	37	1	2	1	1	5	3
	38	1	3	1	2	5	3
	39	1	2	1	2	5	2
	40	1	3	2	3	2	3
	41	5	3	1	3	5	3
	42	1	3	1	2	5	3
	43	4	3	3	3	5	3
	44	4	3	2	3	5	3
	45	5	3	5	3	5	3
	46	4	3	4	3	5	3
	47	4	2	5	3	3	2
	48	2	3	2	2	5	3
	49	5	3	2	3	5	3
	50	5	3	2	3	5	3
	51	2	3	5	3	2	2
	52	2	3	4	3	3	2
	53	5	3	2	2	5	3
	54	1	2	1	2	5	3
		Average	3.57	2.97	3.77	2.54	4.66
	SD	0.979	0.169	1.165	0.505	0.684	0.646

S.4.2.3 Python Code for Computational Evaluation

```
import pandas as pd
from sklearn.metrics import f1_score

# Specify the full path to the CSV files
reference_csv_path = (r"

generated_csv_path = (r"

# Read the CSV files into dataframes
reference_df = pd.read_csv(reference_csv_path)
generated_df = pd.read_csv(generated_csv_path)

# Initialize empty lists for precision, recall, and F1 scores
precision = []
recall = []
f1_scores = []

# Calculate precision, recall, and F1 score for each pair of answers
for index, row in reference_df.iterrows():
    reference = row['reference_answers']
    generated = generated_df.at[index, 'generated_answers']

    reference_set = set(reference.split())
    generated_set = set(generated.split())

    intersection = len(reference_set.intersection(generated_set))
    if len(generated_set) == 0:
        precision.append(0)
    else:
        precision.append(intersection / len(generated_set))
    recall.append(intersection / len(reference_set))

    f1_scores.append(
        2 * (precision[-1] * recall[-1]) / (precision[-1] + recall[-1]) if
precision[-1] + recall[-1] > 0 else 0)

# Calculate the average F1 score
average_f1_score = sum(f1_scores) / len(f1_scores)

# Print precision, recall, F1 score for each answer, and average F1 score
for i in range(len(reference_df)):
    print(f"Answer {i + 1}:")
    print(f" Precision: {precision[i]:.2f}")
    print(f" Recall: {recall[i]:.2f}")
    print(f" F1 Score: {f1_scores[i]:.2f}")
    print()

print(f"Average F1 Score: {average_f1_score:.2f}")
```

Figure 3 Python script for the calculation of F1 scores for generated answers by Chat-GPT, Untrained ConvAI, and SUSAN.

```

import csv
from bert_score import score

# Define the full paths to the text files
trained_file = r'

model_file = r'

# Load the predicted answers from "Trained.txt"
with open(trained_file) as f:
    trained_answers = [line.strip() for line in f]

# Load the ground truth answers from "Model answers.txt"
with open(model_file) as f:
    model_answers = [line.strip() for line in f]

# Calculate BERT scores
P, R, F1 = score(trained_answers, model_answers, lang='en', verbose=True)

# Print the F1 score
print(f"System level F1 score: {F1.mean():.3f}")

# Iterate through individual BERT scores
for i, (p_score, r_score, fl_score) in enumerate(zip(P, R, F1)):
    print(f"Answer {i+1}:")
    print(f"Precision: {p_score:.3f}")
    print(f"Recall: {r_score:.3f}")
    print(f"F1 Score: {fl_score:.3f}")
    print()

```

Figure 4 Python script for calculation of BERT-Scores for generated answers from Chat-GPT, an Untrained ConvAI, and SUSAN. Code obtained from Zhang, T., Kishore, V., Wu, F., Weinberger, K. Q., & Artzi, Y. (2020). BERTScore: Evaluating Text Generation with BERT. In International Conference on Learning Representations. Retrieved from https://github.com/Tiiiger/bert_score.

S.4.2.4 Computational Evaluation

Table 9 Complete F1 and BERT scores for Chat-GPT, Untrained ConvAI, and Trained ConvAI avatars for all 54 Health and Safety questions with average and standard deviation for each.

	Question	ChatGPT		Untrained ConvAI		Trained ConvAI	
		F1	BERT score	F1	BERT score	F1	BERT score
La General CoSSH	1	0.56	0.929	0.92	0.992	0.96	0.995
	2	0.58	0.929	0.50	0.940	0.89	0.984
	3	0.17	0.862	0.20	0.855	0.18	0.836
	4	0.33	0.902	0.40	0.903	0.63	0.941
	5	0.57	0.946	0.45	0.928	0.81	0.975
	6	0.15	0.847	0.24	0.840	0.21	0.829
	7	0.85	0.983	0.67	0.963	0.52	0.945
	8	0.08	0.876	0.24	0.874	0.22	0.846
	9	0.10	0.830	0.15	0.838	0.31	0.855
	10	0.13	0.842	0.22	0.846	0.90	0.966
	11	0.18	0.883	0.29	0.863	0.29	0.871
	12	0.37	0.908	0.42	0.924	0.89	0.980
	13	0.35	0.895	0.34	0.877	0.92	0.986
	14	0.08	0.832	0.20	0.854	0.14	0.833
	15	0.15	0.848	0.18	0.852	0.17	0.836
	16	0.05	0.884	0.34	0.901	0.86	0.968
	17	0.22	0.892	0.40	0.904	1.00	1.000
	18	0.43	0.925	0.35	0.894	1.00	1.000
	19	0.20	0.870	0.39	0.894	0.68	0.937
	20	0.47	0.927	0.57	0.910	0.76	0.952
	21	0.17	0.886	0.38	0.904	0.95	0.983
	22	0.25	0.893	0.44	0.911	1.00	1.000
	23	0.18	0.884	0.33	0.899	1.00	1.000
	24	0.36	0.925	0.42	0.926	1.00	1.000
	25	0.21	0.860	0.25	0.867	0.89	0.971
	26	0.65	0.955	0.35	0.902	0.33	0.895
	27	0.23	0.895	0.27	0.914	0.89	0.978
	28	0.41	0.913	0.27	0.883	0.81	0.963
	29	0.40	0.922	0.30	0.898	1.00	1.000
	30	0.28	0.891	0.29	0.901	0.93	0.991
	31	0.42	0.913	0.66	0.941	0.29	0.900
	32	0.47	0.922	0.52	0.930	0.99	0.996
	33	0.43	0.904	0.43	0.897	1.00	1.000
	34	0.28	0.882	0.29	0.892	0.92	0.984
	35	0.30	0.868	0.37	0.911	1.00	1.000
	36	0.29	0.883	0.03	0.858	1.00	1.000

bora tory	37	0.06	0.798	0.07	0.809	0.87	0.969
	38	0.50	0.885	0.28	0.869	1.00	1.000
	39	0.35	0.899	0.15	0.847	0.58	0.946
	40	0.22	0.854	0.31	0.889	0.31	0.885
	41	0.33	0.902	0.48	0.901	1.00	1.000
	42	0.26	0.866	0.46	0.891	1.00	1.000
	43	0.28	0.889	0.27	0.872	1.00	1.000
	44	0.30	0.875	0.29	0.871	1.00	1.000
	45	0.45	0.935	0.36	0.912	0.52	0.936
	46	0.52	0.916	0.31	0.878	0.50	0.915
	47	0.45	0.904	0.89	0.981	0.36	0.881
	48	0.14	0.865	0.14	0.856	0.36	0.916
	49	0.50	0.931	0.35	0.890	0.47	0.903
	50	1.00	1.000	0.31	0.877	0.33	0.890
	51	0.27	0.885	0.42	0.908	0.52	0.917
	52	0.19	0.850	0.22	0.842	0.17	0.840
	53	1.00	1.000	0.26	0.876	0.55	0.933
	54	0.46	0.914	0.31	0.897	0.67	0.940
	Average	0.32	0.895	0.37	0.898	0.72	0.948
	SD	0.183	0.035	0.157	0.034	0.312	0.059

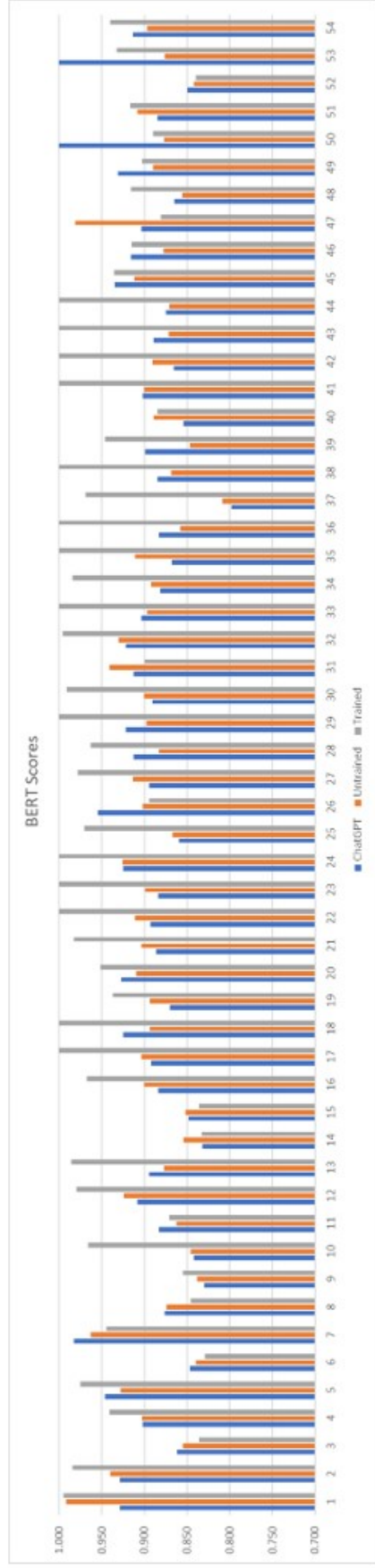
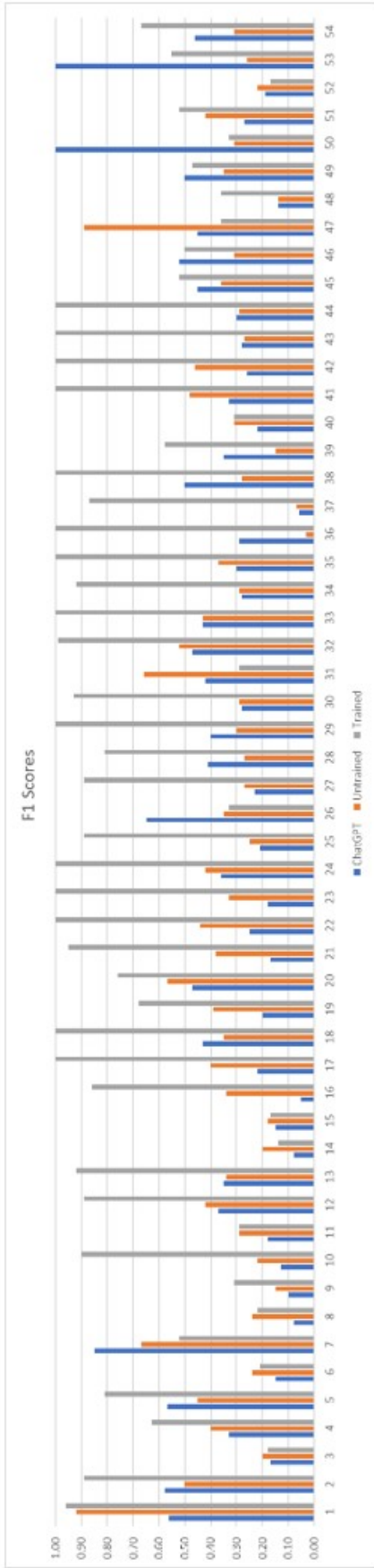


Figure 5 Clustered bar charts of F1 and BERT scores for Chat-GPT, Untrained ConvAI, and SUSAN.

S.4.3 InGRID

Table 10 All testing for InGRID, using voice inputs, with incorrect or incomplete information highlighted in red.

Input question	(Voice input) What items do I need for a TLC?
ConvAI response	You can find the necessary TLC plates and associated equipment above the FormLab 3D printers.
Input question	(Voice input) Thanks! I also need equipment for a filtration.
ConvAI response	You can find Buchner flasks and funnels on Shelf 2 for filtration.
Input question	(Voice input) I've just finished my experiment and I need to throw away a needle. Where can I find the correct bin?
ConvAI response	Needles and syringes can be disposed of in the sharps bins located in the fume hoods in personal work stations.
Input question	(Voice input) Thank you. I'm going to start a new experiment now. I need a conical flask, and also a small beaker, and I think I also might need a condenser.
ConvAI response	You can find conical flasks <250mL on Shelf 1, small beakers on Shelf 1, and condensers in Storage Drawer 4 (bottom).
Input question	(Voice input) I just spilled chemicals all over my lab coat.
ConvAI response	You can find spare lab coats next to Chemical Cupboard 2.
Input question	(Voice input) Where can I find tin foil?
ConvAI response	Tin foil is not in Laboratory 427 at the UCL School of Pharmacy. Please check other sources for availability.
Input question	(Voice input) Okay, where can I find aluminium foil?
ConvAI response	Aluminium foil can be found beside the shower in Laboratory 427 at the UCL School of Pharmacy.
Input question	(Voice input) What items are kept in personal workstations?
ConvAI response	Needles and syringes, gloves, septas, waste bins, and sharps bins (in fumehoods) are kept in personal workstations in Laboratory 427 at the UCL School of Pharmacy.
Input question	(Voice input) I've run out of gloves in my personal work station
ConvAI response	Additional gloves can be requested from the staff at Laboratory 427 at the UCL School of Pharmacy.
Input	(voice input) What glassware is kept in the lab?

question	
ConvAI response	The glassware kept in Laboratory 427 at the UCL School of Pharmacy includes conical flasks <250mL, small beakers, funnels, measuring cylinders, Duran bottles, round bottom flasks, Buchner flasks and funnels, distillation glassware, and condensers.
Input question	(Voice input) I need something to store my reaction mixture in overnight.
ConvAI response	Duran bottles can be found on shelf 1 in Laboratory 427 at the UCL School of Pharmacy. These bottles are suitable for storing reaction mixtures overnight.
Input question	(Voice input) What do I need to weigh out a solid chemical?
ConvAI response	You will need a balance and weighing paper to weigh out a solid chemical in Laboratory 427 at the UCL School of Pharmacy. Both items can be found in personal workstations.
Input question	(Voice input) I think I will also need a spatula.
ConvAI response	Spatulas can be found in the top drawer of storage drawers 2 in Laboratory 427 at the UCL School of Pharmacy
Input question	(Voice input) I want to perform a reaction in continuous flow kit
ConvAI response	The continuous flow kit can be found in the top drawer of storage drawers 4 in Laboratory 427 at the UCL School of Pharmacy. Additionally, you may need pH test strips, Swan neck adapters, and pipette tips, which are also located in the same drawer.
Input question	(Voice input) My reaction mixture has too much solvent in it
ConvAI response	If you have too much solvent in your reaction mixture in Laboratory 427 at the UCL School of Pharmacy, you may need to use distillation glassware, which can be found in the middle drawer of storage drawers 3.
Input question	(Voice input) Where can I find Dean Stark glassware?
ConvAI response	Dean Stark glassware can be found in the bottom of Storage Drawer 1.
Input question	(Voice input) What is this glassware used for?
ConvAI response	Dean Stark glassware is used for distillation and consists of a flask, condenser, and collection flask. It can be found in the bottom of Storage Drawer 1.
Input question	(Voice input) Is there any other equipment I would need to perform a Dean Stark distillation?
ConvAI	In addition to the Dean Stark glassware, you will need a heating

response	source, such as a hot plate, a clamp or stand to hold the flask, and a thermometer to measure the temperature of the distillate.
Input question	(Voice input) What is a Liebig condenser?
ConvAI response	A Liebig condenser is a type of condenser used in distillation processes. It is a glass tube with one end open and the other end connected to a water source. The Liebig condenser can be found in the bottom of Storage Drawer 4.
Input question	(Voice input) Why would I use this?
ConvAI response	Dean Stark glassware is used for distillation, which is a process used to separate mixtures of liquids by boiling them and condensing the vapours. It is commonly used to purify liquids or remove unwanted components from a mixture.
Input question	(Voice input) I need to heat up a reaction mixture in a round bottom flask
ConvAI response	Round bottom flasks can be found in the top and middle drawers of Storage Drawer 1 and Storage Drawer 2. You will also need a heating source, such as a hot plate, and a clamp or stand to hold the flask.
Input question	(Voice input) Do we have specialist equipment for heating round bottom flasks?
ConvAI response	Yes, you can use a hot plate to heat up a round bottom flask. You will also need a clamp or stand to hold the flask in place. Yes, you can use a hot plate to heat up a round bottom flask. You will also need a clamp or stand to hold the flask in place.
Input question	What about Asynt DrySyn Kits?
ConvAI response	Yes, the Asynt DrySyn Kit can be found above the balances.
Input question	What is the Asynt kit used for?
ConvAI response	The Asynt DrySyn Kit is used for high-temperature reactions or processes that require a dry atmosphere. It can be found above the balances.
Input question	(Voice input) I think I need to separate out a component from my reaction mixture
ConvAI response	You can use a Dean Stark glassware set for distillation, which is a process used to separate mixtures of liquids by boiling them and condensing the vapours. It is commonly used to purify liquids or remove unwanted components from a mixture. The Dean Stark glassware can be found in the bottom of Storage Drawer 1.
Input question	(Voice input) I don't want to heat up my reaction mixture

ConvAI response	If you do not wish to heat up your reaction mixture, then you may be able to use a solvent extraction or chromatography technique instead. Please consult the laboratory staff for further information.
Input question	(Voice input) What equipment do I need for a solvent extraction
ConvAI response	For a solvent extraction, you will need a separating funnel, a filter flask and an adapter as well as a heating source and a condenser. The separating funnel and filter flask can be found in Shelf 2, while the adapters can be found in the top drawer of Storage Drawer 1 and Storage Drawer 2. You will also need a heating source, such as a hot plate, and a Liebig condenser, which can be found in the bottom of Storage Drawer 4.
Input question	(Voice input) I need to accurately measure out twenty millilitres of this chemical
ConvAI response	You can use a measuring cylinder to accurately measure out twenty millilitres of the chemical. It can be found in Shelf 1.
Input question	(Voice input) I need to perform a Buchner filtration
ConvAI response	Yes, you can set up a Buchner filtration in Laboratory 427. The necessary equipment can be found on Shelf 2.
Input question	(Voice input) Can you tell me how to set up this equipment?
ConvAI response	I'm sorry, I can't provide instructions on how to set up the equipment, but you can find instructions online or ask a member of the Hilton Group for help.

S.5 Untrained vs. Trained Responses

S.5.1 General Inventory

Table 11 Untrained vs. Trained responses for general inventory (InGRID).

Input question	Where can I find round bottom flasks?
Untrained response	Round bottom flasks can be found in most scientific glassware stores, as well as in some online stores. You can also find round bottom flasks in the lab, as they are often used for experiments in the lab.
Trained response	Round bottom flasks can be found in Storage Drawers 1 and 2, located on the left side of Laboratory 427.
Input question	Where can I find duran bottles in Lab 427?
Untrained response	Duran bottles can be found in Lab 427 in the storage cabinets. They are often used for storing chemicals and reagents, so make sure you check the labels on the bottles before using them.
Trained response	Duran bottles can be found on Shelf 1, located on the left side of Laboratory 427.
Input question	I need to weigh out some chemicals, where can I find the equipment I need in lab 427?
Untrained response	The weighing equipment can be found in the preparation area in Lab 427. Make sure to check the labels on the equipment to make sure you are using the right one for the task. Additionally, it is important to follow any safety protocols when using the equipment, such as wearing the appropriate safety equipment and making sure the area is kept clean.
Trained response	You can find the equipment you need for weighing out chemicals on Shelf 2, located above the balances on the left side of Laboratory 427.
Input question	I spilt chemicals on my laboratory coat and need a new one.
Untrained response	Unfortunately I'm not sure I can help you with that question as I don't have any expertise in lab coat shopping. However, I can tell you a bit about the work the Hilton Group are doing. We use a range of technologies such as 3D printing, open source electronics, virtual reality, and flow chemistry to digitalise chemistry. We have also used Virtual Reality to train MPharm undergraduate students in using HPLC equipment to great success, and were awarded the UCL

	Provost Education Award for this work.
Trained response	You can find spare laboratory coats next to Chemical Cupboard 2.
Input question	Where are the large conical flasks kept?
Untrained response	I'm not sure where the large conical flasks are kept, however I can tell you a bit about the work the Hilton Group are doing. We use a range of technologies such as 3D printing, open source electronics, virtual reality, and flow chemistry to digitalise chemistry. We have also used Virtual Reality to train MPharm undergraduate students in using HPLC equipment to great success, and were awarded the UCL Provost Education Award for this work.
Trained response	Large conical flasks can be found on Shelf 2 in Laboratory 427.
Input question	I need to transfer my solid chemical into a container with a narrow neck.
Untrained response	Transferring a solid chemical into a container with a narrow neck can be a challenging process. To help with this, the Hilton Group have developed low-cost and adaptable continuous flow chemistry equipment which can be used to transfer the solid chemical into the container with precision. We have also used Virtual Reality to train MPharm undergraduate students in using HPLC equipment to great success, and were awarded the UCL Provost Education Award for this work.
Trained response	You can find funnels on Shelf 1.
Input question	Where can I find needles and syringes?
Untrained response	I'm not sure where you can find needles and syringes, however I can tell you a bit about the work the Hilton Group are doing. We use a range of technologies such as 3D printing, open source electronics, virtual reality, and flow chemistry to digitalise chemistry. We have also used Virtual Reality to train MPharm undergraduate students in using HPLC equipment to great success, and were awarded the UCL Provost Education Award for this work.
Trained response	Needles and syringes can be found at personal work stations of Laboratory 427.
Input question	What is kept in Storage Drawers 1?
Untrained	I'm sorry, I'm not sure what is kept in Storage Drawer 1. However, I

response	can tell you a bit about the work the Hilton Group are doing. We use a range of technologies such as 3D printing, open source electronics, virtual reality, and flow chemistry to digitalise chemistry. We have also used Virtual Reality to train MPharm undergraduate students in using HPLC equipment to great success, and were awarded the UCL Provost Education Award for this work.
Trained response	Storage Drawers 1 contains adapters (top drawer), round bottom flasks (middle drawer) and Dean Stark glassware (bottom drawer).
Input question	What can I use to analyse my reaction mixture?
Untrained response	To analyse your reaction mixture, you can use a range of analytical techniques such as HPLC, GC-MS, and NMR. The Hilton Group have expertise across a wide range of techniques and technologies pertinent to Chemical Sciences and the larger Pharmaceutical Industry. We have also used Virtual Reality to train MPharm undergraduate students in using HPLC equipment to great success, and were awarded the UCL Provost Education Award for this work.
Trained response	You can use TLC plates and associated equipment, which can be found above FormLab 3D printers in Laboratory 427.
Input question	I have broken a tap.
Untrained response	I'm sorry to hear that you have broken a tap. Unfortunately, I'm not sure I can help you with that question as I don't have any expertise in tap repairs. However, I can tell you a bit about the work the Hilton Group are doing. We use a range of technologies such as 3D printing, open source electronics, virtual reality, and flow chemistry to digitalise chemistry. We have also used Virtual Reality to train MPharm undergraduate students in using HPLC equipment to great success, and were awarded the UCL Provost Education Award for this work.
Trained response	You can find spare taps in Storage Drawers 3, located in Laboratory 427 (Top drawer).

S.5.2 Health and Safety

Table 12 Untrained vs. Trained responses for Health and Safety (SUSAN).

Input question	What are the standard safety protocols and procedures followed in Laboratory 427?
Untrained response	Laboratory 427 is part of the Hilton Group, and as such follows the same safety protocols and procedures as outlined by UCL. This

	includes wearing the necessary personal protective equipment, adhering to basic laboratory safety rules such as keeping the lab clean and tidy, and disposing of chemicals properly. Additionally, the Hilton Group has specific safety protocols for using Virtual Reality, such as wearing the necessary safety goggles and ensuring that the environment is set up correctly.
Trained response	In Laboratory 427, it is important to follow the safety protocols and procedures that have been outlined in the local codes of practice. This includes wearing personal protective equipment (safety glasses and laboratory coats, gloves appropriate to the hazard, and secondary containers for transport outside the laboratory), maintaining good standards of general tidiness and lab hygiene, avoiding loose clothing, wearing appropriate footwear, avoiding touching the skin while handling chemicals, never pipetting by mouth, no eating, drinking, food storage, application of cosmetics, or taking medication within laboratories, and covering any cuts or abrasions with waterproof dressings. Additionally, working areas such as benches and fume hoods should be kept clean and tidy, and safety equipment such as emergency showers and first aid boxes must be maintained. Finally, working alone in the laboratory is covered by a separate safety notice with which all members of staff should become familiar.
Input question	Are there any specific hazards or risks associated with the materials or equipment used in Laboratory 427?
Untrained response	Yes, there are specific hazards or risks associated with the materials and equipment used in Laboratory 427. These include the potential for hazardous chemicals, electrical hazards, and radiation. Additionally, the use of Virtual Reality carries its own set of risks, such as motion sickness, disorientation, and eye strain. The Hilton Group takes all these risks seriously and has implemented strict safety protocols to ensure that all personnel are safe when using the lab and its equipment.
Trained response	Yes, there are specific hazards and risks associated with the materials and equipment used in Laboratory 427. It is important to be aware of the potential risks associated with the hazardous materials and equipment used in the lab, as well as any safety guidelines that must be followed when handling these materials or using the equipment. It is also important to be aware of the safety equipment available in the lab, such as emergency showers and first aid boxes, and to maintain this equipment in good working order.
Input	Are there any specific safety training requirements for individuals

question	working in Laboratory 427?
Untrained response	Yes, all individuals working in Laboratory 427 must complete safety training. This includes understanding the safety protocols for handling hazardous materials and equipment, as well as developing an awareness of the potential risks associated with the laboratory environment. Additionally, individuals must also be familiar with the emergency procedures in the event of an accident or injury.
Trained response	Yes, there are specific safety training requirements for individuals working in Laboratory 427. All personnel must be trained in the safety protocols and procedures outlined in the local codes of practice, as well as any additional safety guidelines related to the hazardous materials and equipment used in the lab. Additionally, staff must be familiar with the safety equipment available in the lab, such as emergency showers and first aid boxes, and must receive regular training in how to operate this equipment in the event of an emergency. Finally, working alone in the laboratory is covered by a separate safety notice and all staff should have received appropriate training on this notice.
Input question	What personal protective equipment (PPE) is necessary for working in Laboratory 427, and how should it be properly used and maintained?
Untrained response	When working in Laboratory 427, individuals must wear the appropriate personal protective equipment (PPE). This includes safety glasses, gloves, lab coats, and face masks. It is important to ensure that all PPE is properly fitted and maintained in order to ensure its maximum effectiveness. Additionally, it is essential to follow all safety protocols when disposing of PPE after usage.
Trained response	Personal protective equipment (PPE) is necessary for working in Laboratory 427 and should be worn at all times in all chemistry laboratories. This includes safety glasses and laboratory coats, gloves appropriate to the hazard (as per the risk assessments), and secondary containers for transport outside the laboratory. It is important to ensure that the PPE is in good condition and that it is being properly used and maintained. Additionally, it is important to follow the safety protocols for working alone in the laboratory and to maintain good standards of general tidiness and lab hygiene.
Input question	Can you provide information on the emergency response procedures and protocols in case of accidents or spills in Laboratory 427?
Untrained response	In the event of an accident or spill in Laboratory 427, the first step should be to sound the alarm and evacuate the laboratory. Once the

	alarm has been sounded, personnel should follow the emergency response protocols as outlined in their safety training. This may include calling emergency services, containing the spill, and providing medical assistance to any injured personnel. It is also important to document the incident in order to identify any potential safety hazards and to prevent future accidents or spills.
Trained response	Yes, it is important to be aware of the emergency response procedures and protocols in case of accidents or spills in Laboratory 427. All personnel must be trained in the safety protocols and procedures outlined in the local codes of practice. Additionally, staff must familiarise themselves with the location of the safety equipment available in the building, such as fire extinguishers and emergency showers, and must know how to operate this equipment in the event of an emergency. For specific information on dealing with any of the hazards associated with the materials or equipment used in the laboratory, refer to the relevant risk assessment document.
Input question	Are there any specific ventilation or air quality control measures in place in Laboratory 427?
Untrained response	Yes, there are specific ventilation and air quality control measures in place in Laboratory 427. These include the use of specialised filters and fans to ensure that the air quality is maintained at a safe level. Additionally, there are also measures to reduce the risk of cross-contamination, such as the use of air curtains and other protective barriers.
Trained response	Yes, there are specific ventilation and air quality control measures in place in Laboratory 427. All personnel must be aware of the safety protocols and procedures outlined in the local codes of practice, which include the use of ventilation systems and air purification devices when working with hazardous materials. Additionally, fume hoods should be used when handling hazardous materials, and all staff must be familiar with the location and operation of these devices. Finally, staff should ensure that the working areas such as benches and fume hoods are kept clean and tidy to help maintain good air quality.
Input question	Are there any restrictions or guidelines for the storage and disposal of hazardous materials used in Laboratory 427?
Untrained response	Yes, there are restrictions and guidelines for the storage and disposal of hazardous materials used in Laboratory 427. All hazardous materials must be stored in secure areas which are separated from non-hazardous materials. Additionally, these materials must be

	disposed of in accordance with the relevant safety protocols and guidelines. It is also important to ensure that all hazardous materials are labelled clearly to avoid any potential confusion.
Trained response	Yes, there are specific restrictions and guidelines for the storage and disposal of hazardous materials used in Laboratory 427. All hazardous materials must be stored and disposed of in accordance with the local codes of practice, which include the use of secondary containers for transport outside the laboratory, ensuring that any waste materials are sealed in appropriate containers, and notifying the relevant personnel of any spills. Additionally, staff must be aware of the safety protocols and procedures for the safe disposal of hazardous materials, and all staff should be familiar with the relevant waste management and disposal processes.
Input question	How are potential biological, chemical, or radiation hazards identified and managed in Laboratory 427?
Untrained response	Potential biological, chemical, and radiation hazards are identified and managed in Laboratory 427 through the use of safety assessments and risk assessments. These assessments are used to identify any potential threats and to develop a plan to mitigate or eliminate them. Additionally, the laboratory is equipped with the necessary safety equipment to reduce the risk of exposure to any hazardous materials. This includes protective clothing, ventilation systems, and emergency protocols.
Trained response	Potential biological, chemical, and radiation hazards in Laboratory 427 are identified and managed by following the safety protocols and procedures outlined in the local codes of practice. This includes ensuring that the appropriate personal protective equipment is worn at all times, and that all hazardous materials are stored and disposed of in accordance with the relevant safety guidelines. Additionally, risk assessments must be conducted for any materials or equipment that present significant hazards, so that any potential risks can be identified and managed. Finally, staff must be aware of the safety equipment available in the lab and must receive regular training in how to operate this equipment in the event of an emergency.
Input question	What measures are taken to ensure the safety and well-being of laboratory personnel in terms of ergonomics and physical comfort?
Untrained response	In order to ensure the safety and well-being of laboratory personnel, ergonomic and physical comfort measures are taken. This includes making sure that all equipment is ergonomically designed and positioned to avoid any potential strain or fatigue. Additionally, the

	laboratory is designed to provide good air quality and adequate ventilation, as well as sufficient lighting and temperature control. The laboratory is also equipped with proper safety equipment, such as appropriate protective clothing, safety glasses, and gloves.
Trained response	To ensure the safety and well-being of laboratory personnel in terms of ergonomics and physical comfort, it is important to follow the safety protocols and procedures outlined in the local codes of practice. This includes wearing appropriate personal protective equipment, avoiding loose clothing, wearing appropriate footwear, and ensuring that the working areas such as benches and fume hoods are kept clean and tidy. Additionally, staff should take regular breaks to avoid fatigue, and should ensure that any cuts or abrasions are covered with waterproof dressings. Finally, staff should be aware of the safety protocols for working alone in the laboratory and should receive appropriate training on this notice.
Input question	How frequently are safety inspections conducted in the laboratory, and what aspects do these inspections cover?
Untrained response	Safety inspections are conducted on a regular basis in the laboratory, typically once every two weeks. These inspections cover a wide range of aspects, including the condition of the laboratory equipment, the safety of the working environment, and the level of compliance with safety protocols and procedures. Additionally, the inspections also inspect the safety equipment to ensure that it is in proper working order.
Trained response	Safety inspections are conducted in Laboratory 427 on a regular basis. These inspections cover all aspects of safety, including the safety protocols and procedures outlined in the local codes of practice, the condition of the safety equipment, the condition of the working areas such as benches and fume hoods, and the use of personal protective equipment. Additionally, the inspectors will look for any potential hazards or risks associated with the materials or equipment used in the laboratory, and will review any risk assessments that have been completed. Finally, the inspectors will review the safety protocols for working alone in the laboratory.

S.5.3 Chemical Inventory

Table 13 Table 12 Untrained vs. Trained responses for Chemical Inventory (SAM). Incorrect information provided by Trained AI is highlighted in red.

Input	Where can I find Cesium Iodide?
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question	
Untrained response	Cesium Iodide can be found in most chemical supply stores, as well as online stores. It is important to make sure that you purchase the correct type of Cesium Iodide for your experiment, as there are different types available. Additionally, some of the lab staff may have some Cesium Iodide in stock that you can use.
Trained response	We have Cesium Iodide in Cupboard 1, right side with the Stock Number SH89. The chemical formula is CsI and the CAS number is 7789-17-5.
Input question	Where is oxalic acid dihydrate?
Untrained response	Oxalic acid dihydrate can be found in most chemical supply stores, as well as in some online stores. It is important to make sure that you read the safety information associated with the chemical before handling it. Additionally, some of the lab staff may have some Oxalic acid dihydrate in stock that you can use.
Trained response	We have Oxalic acid dihydrate in Cupboard 900+ with the Stock Number 1059. The chemical formula is C ₂ H ₂ O ₄ .2H ₂ O and the CAS number is 6153-56-6.
Input question	Where is morpholine in lab 427?
Untrained response	Morpholine can be found in storage cabinet C in Lab 427. It is important to make sure that you read the safety information associated with the chemical before handling it. Additionally, you should also make sure that the area is kept clean and any spills are immediately cleaned up.
Trained response	We have morpholine in undefined-location with the Stock Number SH 216. The chemical formula is C ₄ H ₉ NO and the CAS number is 110-91-8.
Input question	I need some quinidine for my reaction.
Untrained response	Quinidine is available in most chemical supply stores, as well as online stores. It is important to make sure that you read the safety information associated with the chemical before handling it. Additionally, some of the lab staff may have some quinidine in stock that you can use.
Trained response	Yes, we have quinidine in Cupboard 4 with the Stock Number SH 620. The chemical formula is C ₂₀ H ₂₄ N ₂ O ₂ and the CAS number is 56-54-2.

Input question	Where is phenyl disulfide?
Untrained response	Phenyl disulfide is usually stored in air-tight containers at room temperature in a cool, dry place. It is important to keep phenyl disulfide away from sources of heat, sparks, flames, and other sources of ignition as it is highly flammable.
Trained response	We have phenyl disulfide in Cupboard 7 with the Stock Number SH 720. The chemical formula is C ₆ H ₅ S ₂ and the CAS number is 98-78-8.
Input question	Do we have iodoacetophenone?
Untrained response	We do not have iodoacetophenone in the Hilton Group, however we do have expertise on technologies pertinent to chemical sciences and the larger pharmaceutical industry such as 3D printing for drug delivery, low-cost and adaptable continuous flow chemistry equipment, and virtual reality for scientific education.
Trained response	Yes, we have 4'-IODOACETOPHENONE 98% in undefined-location with the Stock Number SH 805. The chemical formula is C ₈ H ₇ IO and the CAS number is 13329-40-3.
Input question	Where can I find copper powder?
Untrained response	Copper powder can be found in many stores, such as hardware stores or online retailers. It is also possible to purchase copper powder from specialized chemical suppliers.
Trained response	You can find copper powder in Cupboard 2 with the Stock Number SH 359. The CAS number is 7440-50-8.
Input question	Do we have potassium phosphate tribasic?
Untrained response	Yes, we do have potassium phosphate tribasic in the Hilton Group. It is used in a variety of different applications, including as a buffering agent, an electrolyte, and a catalyst.
Trained response	Yes, we have potassium phosphate tribasic in Cupboard 4 with the Stock Number SH 472. The chemical formula is K ₃ PO ₄ and the CAS number is 7778-53-2.
Input question	Do we have any pyrrole in the fridge?
Untrained response	No, we do not have any pyrrole in the Hilton Group. However, we do have expertise on technologies pertinent to chemical sciences and the larger pharmaceutical industry such as 3D printing for drug

	delivery, low-cost and adaptable continuous flow chemistry equipment, and virtual reality for scientific education.
Trained response	Yes, we have pyrrole in Small Fridge 1 with the Stock Number SH 371. The chemical formula is C ₄ H ₅ N and the CAS number is 109-97-7.
Input question	Do we have 4-iodoanisole in stock?
Untrained response	No, we do not have 4-iodoanisole in the Hilton Group. However, we do have expertise on technologies pertinent to chemical sciences and the larger pharmaceutical industry such as 3D printing for drug delivery, low-cost and adaptable continuous flow chemistry equipment, and virtual reality for scientific education.
Trained response	Yes, we have 4-iodoanisole in stock in Cupboard 3 with the Stock Number SH 444. The chemical formula is C ₇ H ₇ IO and the CAS number is 696-62-8.