# A-Level Chemistry

## Organic

## Practical Questions

### Question Paper

**Time available: 122 minutes**
**Marks available: 99 marks**

**1.** This question is about the analysis of organic compounds.

For each pair of compounds in parts (a) and (b), give a reagent (or combination of reagents) that could be added separately to each compound in a single reaction to distinguish between them.

State what is observed in each case.

(a) $CH_3CH_2CH_2CHO$ and $CH_3CH_2CH(OH)CH_3$

Reagent(s) _____

Observation with $CH_3CH_2CH_2CHO$ _____

_____

Observation with $CH_3CH_2CH(OH)CH_3$ _____

_____

**(3)**

(b) Cyclohexane and cyclohexene

Reagent(s) _____

Observation with cyclohexane _____

_____

Observation with cyclohexene _____

_____

**(3)**

(c) The table below gives the precise relative molecular masses ($M_r$) of some organic compounds measured using high resolution mass spectrometry.

| **Molecular formula** | $C_5H_{12}$ | $C_5H_{10}$ | $C_6H_6$ |
|---|---|---|---|
| $\boldsymbol{M_r}$ | 72.1416 | 70.1260 | to be calculated |

Use these data to find the relative atomic masses ($A_r$) of hydrogen and carbon. Give your answers to 4 decimal places.

Use these calculated $A_r$ values to find the relative molecular mass ($M_r$) of $C_6H_6$ Give your answer to 4 decimal places.

$A_r$ of hydrogen _____

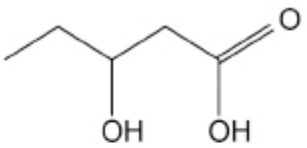
$A_r$ of carbon _____

$M_r$ of $C_6H_6$ _____

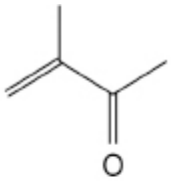
**(3)**

**(Total 9 marks)**

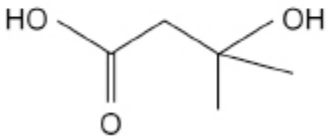
**2.** A student plans a series of chemical tests to confirm the identities of four organic liquids.




Liquid **J**




Liquid **K**




Liquid **L**


Liquid **M**

This is the student's method.

To separate test tubes containing samples of each liquid:

**Test 1** add potassium dichromate(VI) solution and warm gently

**Test 2** add Fehling's solution and cool in iced water

**Test 3** add sodium hydrogencarbonate solution and test any gas produced with a lighted splint

**Test 4** add bromine water and shake at room temperature.

(a) Identify the missing reagent needed in **Test 1**.

_____

**(1)**

(b) In addition to the missing reagent in **Test 1**, there is a mistake in the method for **two** of the other tests.

State the **two** mistakes.

Suggest how each of the mistakes should be corrected.

Mistake 1 _____

Suggestion _____

_____

Mistake 2 _____

Suggestion _____

_____

**(2)**

(c) The missing reagent is added and the mistakes are corrected.

Identify the liquid(s), **J**, **K**, **L** and **M**, that would react in each test.

State the expected observation for each reaction.

Liquid(s) that react in **Test 1** _____

Expected observation _____

_____

Liquid(s) that react in **Test 2** _____

Expected observation _____

_____

Liquid(s) that react in **Test 3** _____

Expected observation _____

_____

Liquid(s) that react in **Test 4** _____

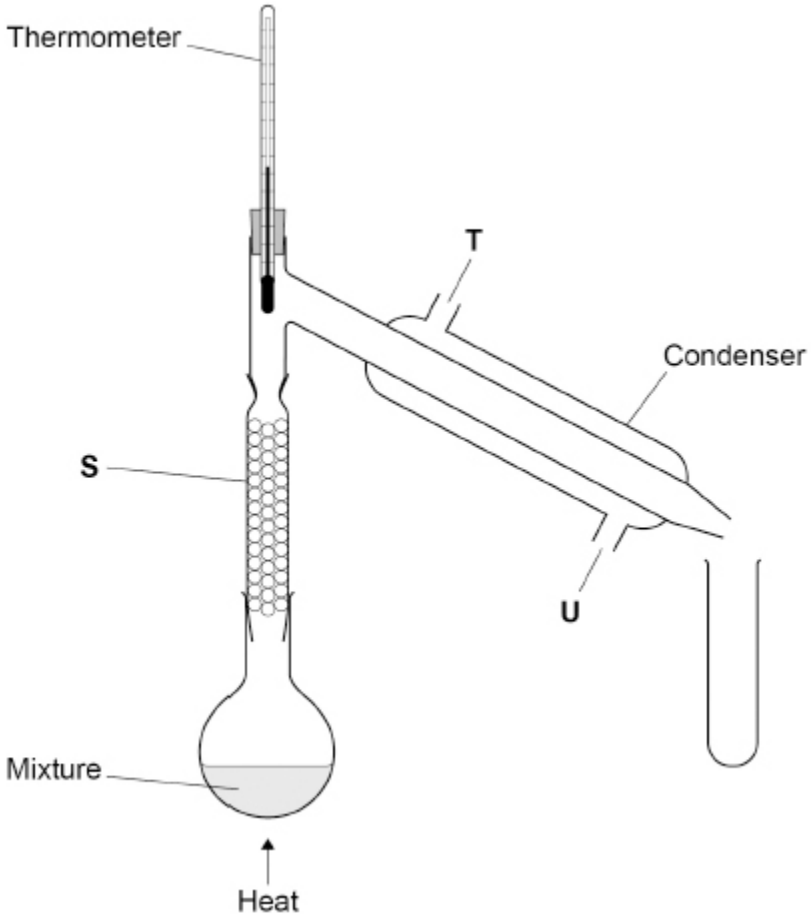
Expected observation _____

**(8)**

(d) The figure below shows the apparatus that is used to separate a mixture of liquids **K** and **M** using fractional distillation.

Suggest labels that should be added to positions **S**, **T** and **U** in the figure.

Explain why fractional distillation is preferred to simple distillation to separate liquids **K** and **M**.




Label **S** _____

Label **T** _____

Label **U** _____

Explanation _____

_____

**(3)**

**(Total 14 marks)**

**3.** Endomorphin-2 is a peptide with the amino acid sequence shown.

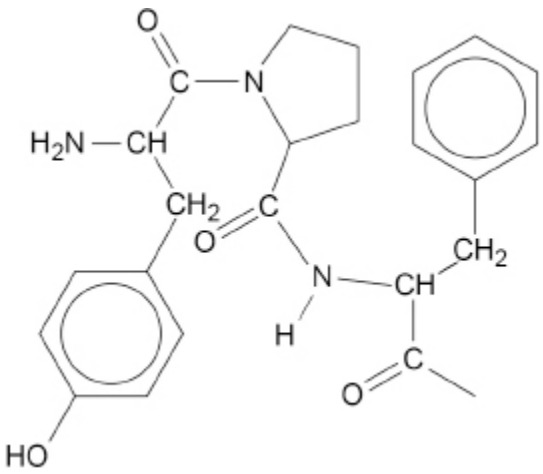
Tyr–Pro–Phe–Phe–$NH_2$

Each amino acid is represented by a three-letter abbreviation.

Tyr = tyrosine Pro = proline Phe = phenylalanine

**Figure 1** shows part of the structure of endomorphin-2, showing the Tyr–Pro–Phe– part of the molecule.

**Figure 1**




(a) The $–NH_2$ at the end of the amino acid sequence of endomorphin-2 shows that the terminal functional group is an amide, not an acid.

Complete the structure of endomorphin-2 in **Figure 1**.

**(2)**

(b) Use the structure in **Figure 1** to draw the skeletal formula of proline, Pro.

**(1)**

A student hydrolyses a sample of endomorphin-2 to break it down into its constituent amino acids.

The student analyses the resulting mixture by thin-layer chromatography, TLC.

(c) State a reagent and the conditions needed for the hydrolysis.

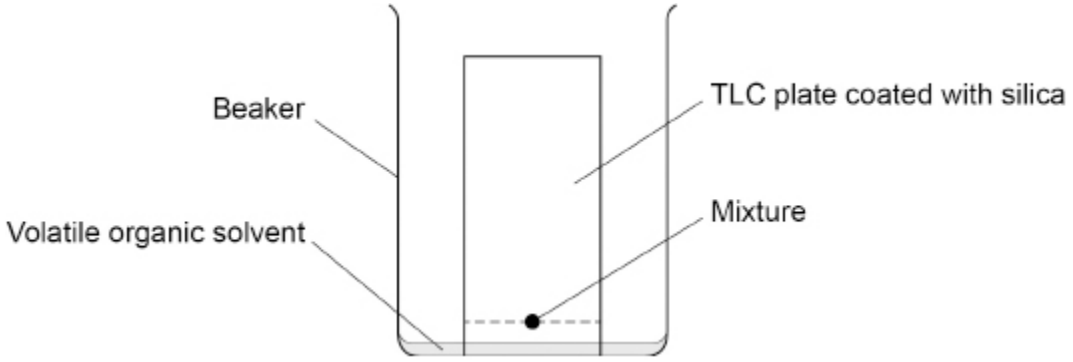
Reagent _____

Conditions _____

**(2)**

(d) **Figure 2** shows the apparatus used for the TLC.

**Figure 2**




There is a piece of the apparatus missing from **Figure 2**. This omission will result in an inaccurate chromatogram.

Identify the missing piece of the apparatus.

State and explain why this piece of the apparatus is needed.

Missing piece _____

Explanation _____

_____

_____

_____

**(3)**

(e) State why the amino acids separate on the TLC plate.

_____

_____

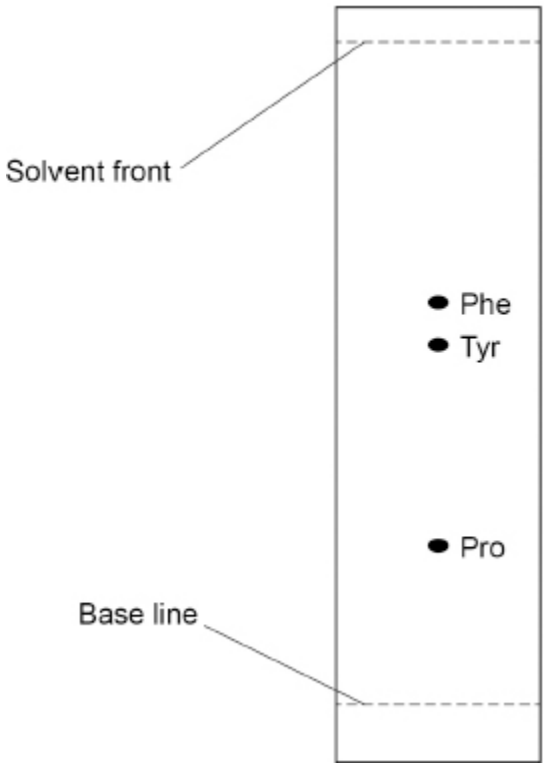
_____

**(1)**

When the solvent has risen up the TLC plate, the student removes the plate from the beaker and sprays it with a developing agent.

**Figure 3** shows the result.

**Figure 3**




(f) Name a suitable developing agent.

State why the developing agent is needed.

Name _____

Why needed _____

_____

_____

**(2)**

(g) Determine the $R_f$ value for Tyr.

$R_f$ _____

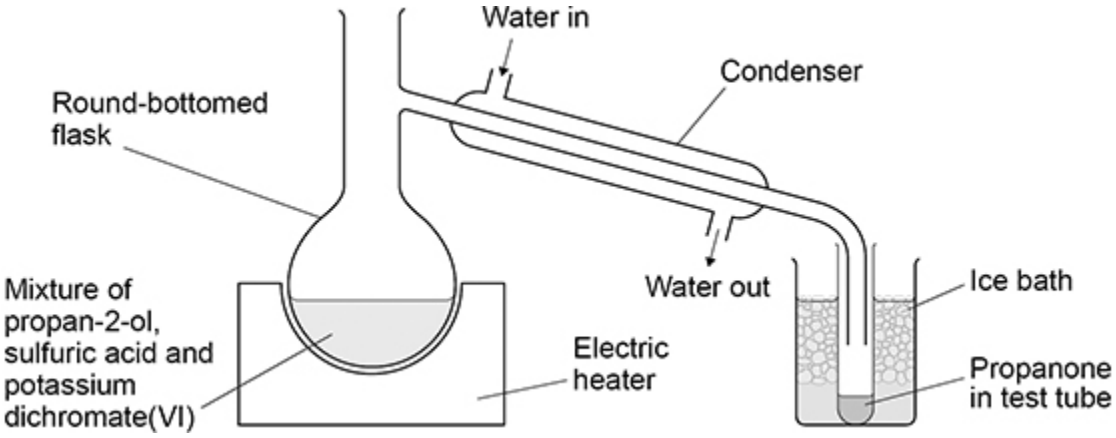
**(1)**

**(Total 12 marks)**

**4.** Propanone can be made by reacting propan-2-ol with an excess of acidified potassium dichromate(VI).

The propanone is removed from the reaction mixture by distillation.

(a) The figure below shows the apparatus set up by a student to make propanone by this method. Suitable clamps are used to hold all the apparatus firmly in place.




There are **three** problems with the apparatus set up in the figure above.

For each problem:

- identify the problem
- describe the issue it would cause
- suggest how the problem can be solved.

**(6)**

Another student completes the experiment using apparatus that is set up correctly.

(b) The student reacts 2.0 $cm^3$ of propan-2-ol ($CH_3CH(OH)CH_3$) with an excess of acidified potassium dichromate(VI).

The student obtains 0.954 g of propanone ($CH_3COCH_3$).

Calculate the percentage yield of propanone in this experiment.
Give your answer to the appropriate number of significant figures.

Density of propan-2-ol = 0.786 g $cm^{-3}$

Percentage yield _____

**(4)**

(c) Molecules of propan-2-ol and propanone each contain three carbon atoms.

Complete the table below to suggest the shape and a bond angle around the central C atom in a molecule of each compound.

| Compound | propan-2-ol $CH_3CH(OH)CH_3$ | propanone $CH_3COCH_3$ |
|---|---|---|
| Shape around central C atom | | |
| Bond angle around central C atom | | |

**(2)**

(d) Explain why propanone has a lower boiling point than propan-2-ol.

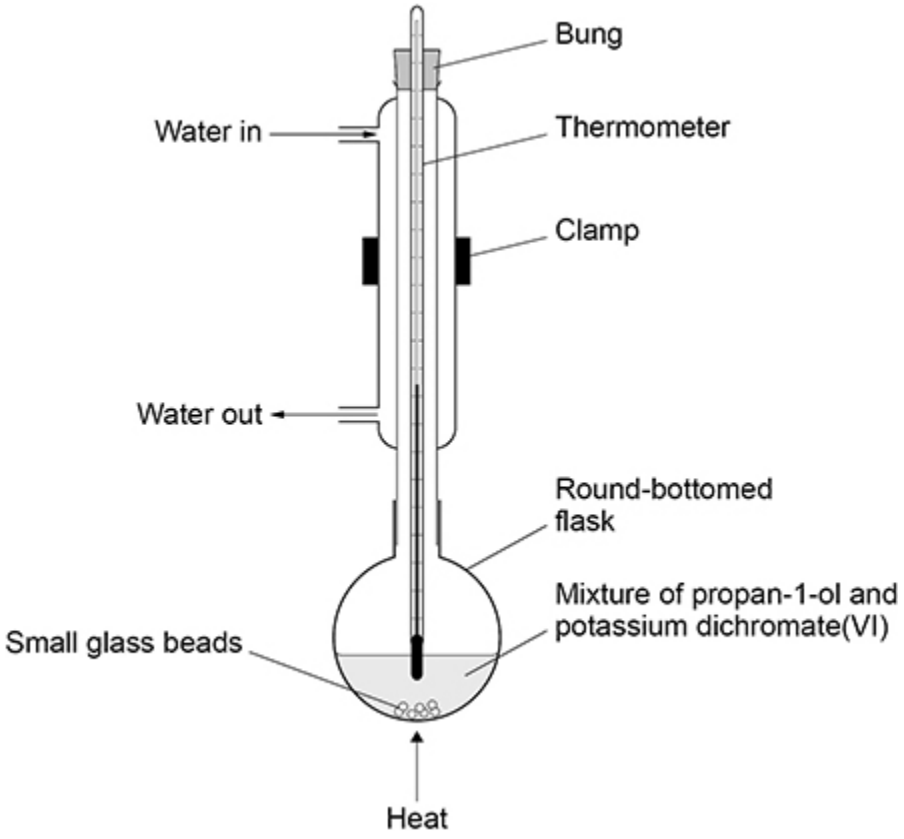
**(3)**

**(Total 15 marks)**

**5.** A student plans an experiment to investigate the yield of propanoic acid when a sample of propan-1-ol is oxidised.

The figure below shows the apparatus that the student plans to use for the experiment.

The student's teacher says that the apparatus is not safe.



(a) Give **two** reasons why the apparatus shown in above figure is not safe.

1 _____

_____

2 _____

_____

**(2)**

(b) Give **one** additional reagent that is needed to form any propanoic acid.

_____

**(1)**

(c) State **two** more mistakes in the way the apparatus is set up in above figure.

1 _____

_____

2 _____

_____

**(2)**

(d) State the purpose of the small glass beads in the flask in above figure.

_____

_____

_____

**(1)**

(e) After correcting the mistakes, the student heats a reaction mixture containing 6.50 g of propan-1-ol with an excess of the oxidising agent.
The propanoic acid separated from the reaction mixture has a mass of 3.25 g

State the name of the technique used to separate the propanoic acid from the reaction mixture.

Calculate the percentage yield of propanoic acid.

Technique _____

Percentage yield _____

**(4)**

(f) State a simple chemical test that distinguishes the propanoic acid from the propan-1-ol.

Give **one** observation for the test with each substance.

Test _____

Propanoic acid _____

Propan-1-ol _____

**(3)**

**(Total 13 marks)**

**6.** Aspirin can be produced by reacting salicylic acid with ethanoic anhydride.
An incomplete method to determine the yield of aspirin is shown.

**1.** Add about 6 g of salicylic acid to a weighing boat.
**2.** Place the weighing boat on a 2 decimal place balance and record the mass.
**3.** Tip the salicylic acid into a 100 $cm^3$ conical flask.
**4.** _____
**5.** Add 10 $cm^3$ of ethanoic anhydride to the conical flask and swirl.
**6.** Add 5 drops of concentrated phosphoric acid.
**7.** Warm the flask for 20 minutes.
**8.** Add ice-cold water to the reaction mixture and place the flask in an ice bath.
**9.** Filter off the crude aspirin from the mixture and leave it to dry.
**10.** Weigh the crude aspirin and calculate the yield.

(a) Describe the instruction that is missing from step **4** of the method.

Justify why this step is necessary.

Instruction _____

Justification _____

_____

_____

**(2)**

(b) Suggest a suitable piece of apparatus to measure out the ethanoic anhydride in step **5**.

_____

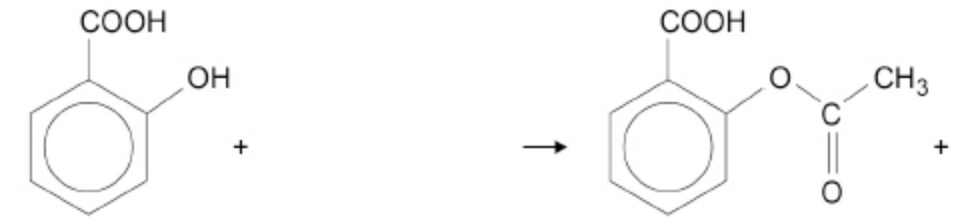
**(1)**

(c) Identify a hazard of using concentrated phosphoric acid in step **6**.

_____

**(1)**

(d) Complete the equation for the reaction of salicylic acid with ethanoic anhydride to produce aspirin.




Salicylic acid Aspirin

**(1)**

(e) A 6.01 g sample of salicylic acid ($M_r$ = 138.0) is reacted with 10.5 $cm^3$ of ethanoic anhydride ($M_r$ = 102.0).
In the reaction the yield of aspirin is 84.1%

The density of ethanoic anhydride is 1.08 g $cm^{-3}$

Show by calculation which reagent is in excess.

Calculate the mass, in g, of aspirin ($M_r$ = 180.0) produced.

Reagent in excess _____

Mass of aspirin _____ g

**(5)**

(f) Suggest **two** ways in which the melting point of the crude aspirin collected in step **9** would differ from the melting point of pure aspirin.

Difference 1 _____

_____

Difference 2 _____

_____

**(2)**

(g) The crude aspirin can be purified by recrystallisation using hot ethanol (boiling point = 78 °C) as the solvent.

Describe **two** important precautions when heating the mixture of ethanol and crude aspirin.

Precaution 1 _____

_____

Precaution 2 _____

_____

**(2)**

(h) The pure aspirin is filtered under reduced pressure.
A small amount of cold ethanol is then poured through the Buchner funnel.

Explain the purpose of adding a small amount of cold ethanol.

_____

_____

_____

**(1)**

(i) A sample of the crude aspirin is kept to compare with the purified aspirin.

Describe **one** difference in appearance you would expect to see between these two solid samples.

_____

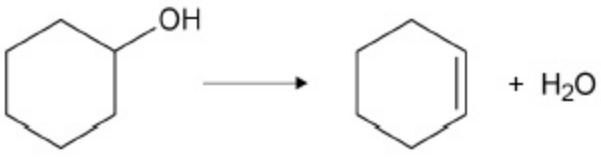
_____

_____

**(1)**

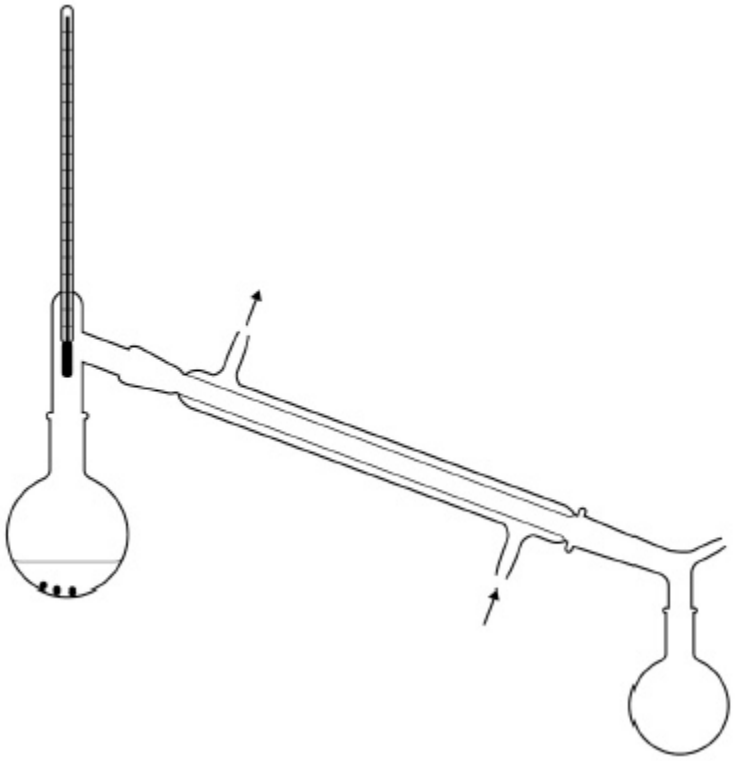
**(Total 16 marks)**

**7.** Cyclohexene (boiling point = 83 °C) can be prepared by the dehydration of cyclohexanol (boiling point = 161 °C) using concentrated phosphoric acid.




A student prepared cyclohexene by placing 10 $cm^3$ of cyclohexanol (density = 0.96 g $cm^{-3}$) into a round-bottomed flask.

3 $cm^3$ of concentrated phosphoric acid were then carefully added to the flask.
The student added a few anti-bumping granules and set up the apparatus shown in the diagram.



- The student heated the mixture and collected the liquid that distilled at temperatures below 100 °C
- The distillate was poured into a separating funnel and washed by shaking with sodium carbonate solution.
- Periodically, the separating funnel was inverted and the tap opened.
- The aqueous layer was discarded and the final organic product was dried using anhydrous calcium chloride.
- After the product was dried, the drying agent was removed by filtration under reduced pressure.

(a) The student collected 5.97 g of cyclohexene in the experiment.

Calculate the percentage yield of cyclohexene.

Percentage yield _____ %

**(3)**

(b) Describe a test-tube reaction, on the product, to show that the cyclohexanol had been dehydrated.

State what you would observe. _____

_____

_____

_____

**(2)**

(c) Suggest why sodium carbonate solution was used to wash the distillate.

_____

_____

_____

**(1)**

(d) Explain why it is important to open the tap of the separating funnel periodically.

_____

_____

_____

**(1)**

(e) Give a property of anhydrous calcium chloride, other than its ability to absorb water, that makes it suitable as a drying agent in this preparation.

_____

_____

_____

**(1)**

(f) Describe the apparatus used to remove the drying agent by filtration under reduced pressure. Your description of the apparatus can be either a labelled diagram or a description in words.

**(2)**

(g) A sample of cyclohexene has been contaminated with cyclohexanol. The cyclohexene can be separated from the cyclohexanol by column chromatography.
Silica gel is used as the stationary phase and hexane as the mobile phase.

Explain why cyclohexene has a shorter retention time than cyclohexanol.

**(2)**

(h) Explain how an infrared spectrum would confirm that the cyclohexene obtained from the chromatography column did not contain any cyclohexanol.

**(1)**

**(Total 13 marks)**

**8.** Propane-1,2-diol has the structure $CH_2(OH)CH(OH)CH_3$. It is used to make polyesters and is one of the main substances in electronic cigarettes (E-cigarettes).

A sample of propane-1,2-diol was refluxed with a large excess of potassium dichromate(VI) and sulfuric acid.

(a) Draw the skeletal formula of propane-1,2-diol.

**(1)**

(b) Write an equation for this oxidation reaction of propane-1,2-diol under reflux, using [O] to represent the oxidizing agent.

Show the displayed formula of the organic product.

_____

**(2)**

(c) Draw a labelled diagram to show how you would set up apparatus for refluxing.

**(2)**

(d) Anti-bumping granules are placed in the flask when refluxing.
Suggest why these granules prevent bumping.

_____

_____

_____

**(1)**

(e) Draw the structure of a different organic product formed when the acidified potassium dichromate(VI) is not in excess.

**(1)**

**(Total 7 marks)**