

Victorian Certificate of Education

CHEMISTRY 2026 Unit 1 and 2

End of Year Examination

Reading time: 10 minutes

Writing time: 120 minutes

Student's Name: _____

Teacher: _____

Structure of booklet

Section	Question to be answered	Total marks
Multiple choice	20	25
Short answer	12	72
Total		97

Directions to students

Materials

- Students are permitted to bring into the examination room: pencils, highlighters, erasers, sharpeners, **rulers**, and an approved scientific calculator.
- Students are NOT permitted to bring into the examination room: white out liquid/tape, phones or electronic devices, including smart watches.
- Students are provided with the following: Question and answer book of 24 pages and VCAA Data booklet.

The task

- Please ensure that you write your name and teacher's name on this booklet. This paper consists of Part A (25 multiple choice questions) to be answered on the answer sheet found on page 9 and Part B (12 short answer questions)
- There are a total of **97** marks available.
- Be sure to include states with all chemical equations.
- All numerical answers need to be quoted to the correct number of significant figures.
- All working out must be shown in the space provided for marks to be awarded

Section A – Multiple Choice Questions

Question 1

Which of the following atoms has the greatest number of neutrons?

- a) ^{56}Mn
- b) ^{56}Ni
- c) ^{57}Co
- d) ^{58}Fe

Question 2

The element nitrogen is able to form the nitride ion $^{15}\text{N}^{3-}$. Which of the following statements about this ion is **incorrect**?

- a) There are more neutrons than protons in the ion
- b) The number of neutrons in the ion is greater than the number of electrons
- c) The uncharged nitrogen atom has the same number of protons as the ion.
- d) The number of electrons in the ion is greater than the ion's atomic number.

Question 3

All alkenes have

- a) only single covalent bonds
- b) one or more C=C double covalent bonds
- c) similar size and shaped molecules
- d) no more than one double bond

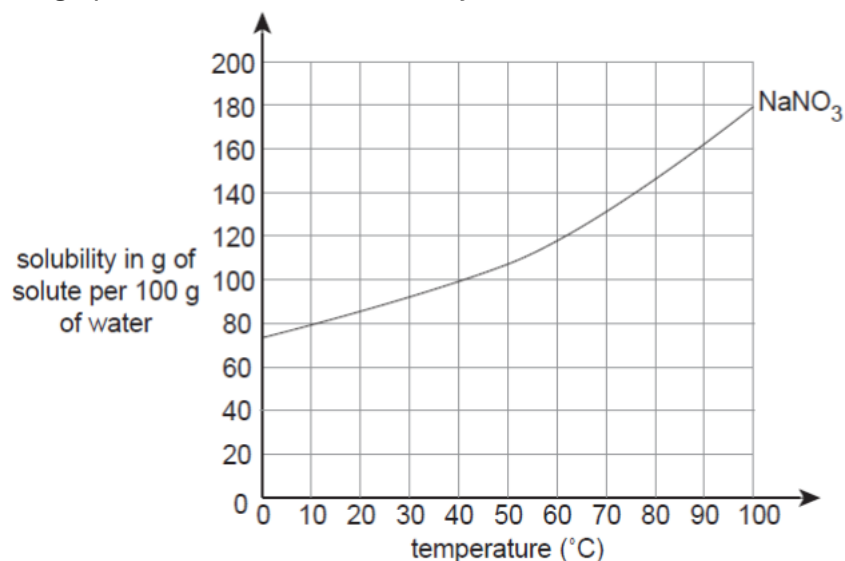
Question 4

Methanol dissolves completely in water. This is best attributed to:

- a) the formation of ion-dipole interactions that result when methanol ionises in water.
- b) hydrogen bonds forming between the water molecules and the methyl groups in methanol.
- c) the formation of dispersion forces between the water and methanol molecules.
- d) the hydroxyl groups in methanol forming hydrogen bonds with the water molecules.

Question 5

The graph below shows the solubility curve for NaNO_3 .



A 70.0mL saturated solution of NaNO_3 was cooled from 90°C to 40°C.

The mass of NaNO_3 (in grams) expected to crystallise from the solution is closest to:

- a) 40
- b) 60
- c) 70
- d) 100

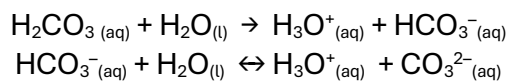
Question 6

A student added an unknown aqueous solution to an aqueous solution of barium chloride (BaCl_2) and observed the formation of a precipitate. The unknown aqueous solution could have contained:

- a) copper(II) nitrate.
- b) lithium ethanoate.
- c) ammonium sulfate.
- d) potassium iodide.

Question 7

Carbonic acid, H_2CO_3 , can react with water in two stages:



From the equations above it is evident that

- a) H_3O^+ is the conjugate base of H_2CO_3 .
- b) H_2CO_3 is amphiprotic as it reacts in two stages.
- c) HCO_3^- is diprotic as it is involved in two reactions.
- d) H_2CO_3 is diprotic

Question 8

If this unbalanced equation $\text{C}_2\text{H}_5\text{OH}_{(l)} + \text{O}_{2(g)} \rightarrow \text{CO}_{2(g)} + \text{H}_2\text{O}_{(g)}$ is balanced, the coefficients in order from left to right would be

- a) 2, 7, 4, 6
- b) 1, 3, 2, 3
- c) 2, 3, 2, 3
- d) 1, 2, 2, 2

Question 9

A solution of NaOH, is to be used to neutralise the contents of three beakers.

Beaker A: 10 mL of 1.0 M HCl

Beaker B: 1.5 mL of 10 M HCl

Beaker C: 1000 mL of 0.0001 M HCl

From **lowest** to **highest**, what will be the volume of NaOH required to neutralise each beaker?

- a) beaker C, beaker B, beaker A
- b) beaker B, beaker A, beaker C
- c) beaker C, beaker A, beaker B
- d) Not able to be determined as the concentration of the NaOH is not known.

Question 10

Which one of the following is an example of a solution of a strong acid that is dilute?

- a) 2mL of 0.005 M HNO_3
- b) 2L of 5M NaOH
- c) 500 mL of 2M CH_3COOH
- d) 10mL of 5M H_2SO_4

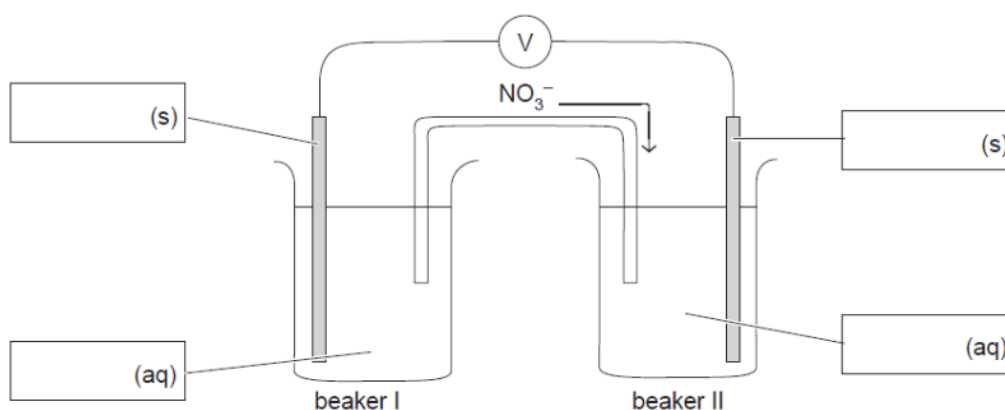
Question 11

The number of hydrogen atoms present in 2.0g of methane is

- a) 7.5×10^{22}
- b) 3.0×10^{23}
- c) 1.2×10^{24}
- d) 4.8×10^{24}

The following information relates to Question 12 and 13.

An electrochemical cell used to produce an electric current was constructed using two standard half-cells $\text{Pb}^{2+}_{(\text{aq})}/\text{Pb}_{(\text{s})}$ and $\text{Fe}^{2+}_{(\text{aq})}/\text{Fe}_{(\text{s})}$. The two half-cells were joined by a salt bridge soaked in a solution of potassium nitrate. The arrangement is shown in the diagram below.

**Question 12**

It was found that when a current was generated, nitrate ions from the salt bridge flowed into Beaker II, as shown in the diagram above.

The species reacting in beaker I when the current is flowing is

- a) $\text{Fe}_{(\text{s})}$
- b) $\text{Pb}^{2+}_{(\text{aq})}$
- c) $\text{Pb}_{(\text{s})}$
- d) $\text{Fe}^{2+}_{(\text{aq})}$

Question 13

The electrode in Beaker II in this galvanic cell is

- a) the positively charged anode.
- b) the positively charged cathode.
- c) the negatively charged cathode.
- d) the negatively charged anode.

Question 14

The reaction that occurs when a piece of clean magnesium metal is placed in water can be described by the chemical equation:



In this reaction the magnesium is acting as the:

- a) reductant because it is donating electrons.
- b) reductant because it is accepting electrons.
- c) oxidant because it is donating electrons.
- d) oxidant because it is accepting electrons.

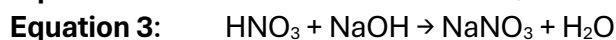
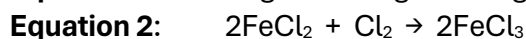
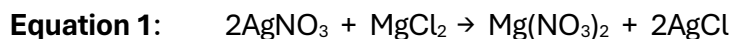
Question 15

The oxidation number of the vanadium in the compound K_2VF_6 will be:

- a) -6
- b) -4
- c) +4
- d) +6

Question 16

Consider the following reactions below:



Which one of the following statements about these reactions is correct?

- a) Equation 1 is a redox reaction because the oxidation number of the Cl has changed.
- b) Equation 2 is a redox reaction because oxidation number changes are evident.
- c) Equation 3 is a precipitation reaction because NaNO_3 will be insoluble.
- d) Equation 2 is a precipitation reaction because FeCl_3 is insoluble.

Question 17

Calculate the pH of an 0.0100 M calcium hydroxide, $\text{Ca}(\text{OH})_2$ solution, at 25°C.

- a) 0.3
- b) 2.0
- c) 12.0
- d) 12.3

Question 18

The mass (in grams) of 0.150 mol of butanoic acid is

- a) 9.00
- b) 11.1
- c) 11.4
- d) 13.2

Question 19

The **amount**, in mol of sodium ions in 1.64g of sodium phosphate, Na_3PO_4 is closest to:

- a) 0.0100
- b) 0.0300
- c) 1.00
- d) 3.00

Question 20

Some enthusiastic CGS Year 11 students set out to determine the empirical formula of black copper oxide. They started with 2.65g of black copper oxide which was converted in a series of reactions to metallic copper. The mass of dry copper obtained was 2.12g. The empirical formula of the oxide is:

- a) CuO
- b) Cu_2O
- c) Cu_3O_4
- d) CuO_2

Question 21

Electronegativity is best described as

- a) the ability of an ion to attract protons.
- b) the ability of an atom to become a charged ion.
- c) the ability of an atom to attract electrons.
- d) the ability of an ion to conduct electricity.

Question 22

Which of the following identifies the nature of the bonds in a molecule of CCl_4 and the overall level of polarity of the molecule?

- a) polar bonds and polar molecule
- b) polar bonds and non-polar molecule
- c) non-polar bonds and polar molecule
- d) non-polar bonds and non-polar molecule

Question 23

10.0g of sodium hydroxide is dissolved in 400mL of water. What will the NaOH concentration, in M be?

- a) 0.10
- b) 0.625
- c) 6.25×10^{-4}
- d) 2.500

Question 24

A saline solution that is used as an emergency eyewash is made by adding 0.95 g of sodium chloride, NaCl, to water and making the volume up to 10 mL with water. In this solution, the NaCl concentration can be expressed as:

- a) 9.5% m/v
- b) 0.95% m/v
- c) 9.5% v/v
- d) 95% m/v

Question 25

Which of the following shows the volume of water, in mL, which must be **added** to 150 mL of a 0.340M NaCl solution in order to produce a 0.204M NaCl solution?

- a) 54
- b) 90
- c) 100
- d) 250

End of Section A

Multiple choice answer sheet.
Circle one correct response for each question.
Do not remove from the examination paper.

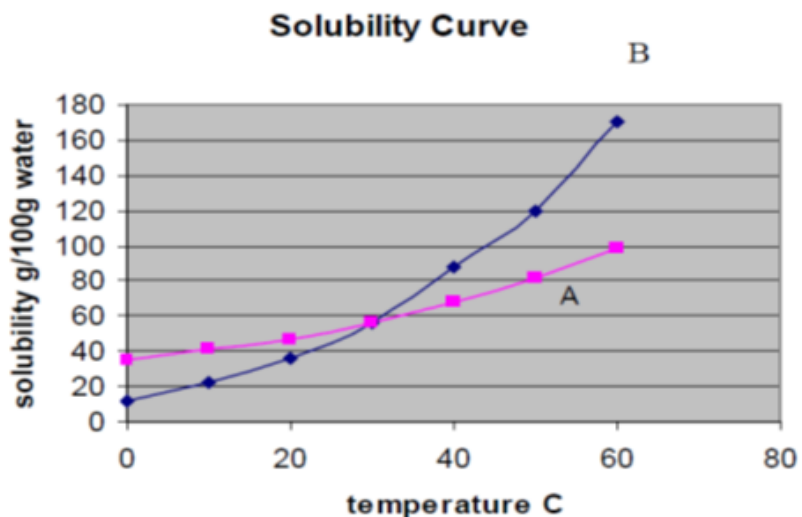
Name _____

- | | | | | |
|-----|---|---|---|---|
| 1. | A | B | C | D |
| 2. | A | B | C | D |
| 3. | A | B | C | D |
| 4. | A | B | C | D |
| 5. | A | B | C | D |
| 6. | A | B | C | D |
| 7. | A | B | C | D |
| 8. | A | B | C | D |
| 9. | A | B | C | D |
| 10. | A | B | C | D |
| 11. | A | B | C | D |
| 12. | A | B | C | D |
| 13. | A | B | C | D |
| 14. | A | B | C | D |
| 15. | A | B | C | D |
| 16. | A | B | C | D |
| 17. | A | B | C | D |
| 18. | A | B | C | D |
| 19. | A | B | C | D |
| 20. | A | B | C | D |
| 21. | A | B | C | D |
| 22. | A | B | C | D |
| 23. | A | B | C | D |
| 24. | A | B | C | D |
| 25. | A | B | C | D |

Section B – Short Answer Questions

Question 1 (6 marks)

The solubility curves for two ionic substances, A and B, are drawn below.



- a. A saturated solution of substance B contains 170g of solid in 100g of water. What temperature is the solution?

(1 mark)

- b. A saturated solution contains 40 g of solid in 200 g of water at 10°C. Which substance, A or B, must be in the solution? Justify your answer.

(2 marks)

- c. What mass of substance B could be dissolved in 1.0 kg of water at 50°C?

(2 marks)

- d. A saturated solution of substance A at 60°C contains 40 g of compound A. What mass of water was used to prepare this solution?

(1 mark)

Continue over the page

Question 2 (10 marks)

The ability to write balanced chemical equations is very important in Unit 2 Chemistry. Each topic of the course requires equations to explain the reactions that are occurring.

- a. Scientists often dip fossils in hydrochloric acid, HCl. If a gas is produced, the fossil probably contains calcium carbonate, CaCO_3 . Write a balanced chemical equation for the reaction between HCl and CaCO_3 . Include states.

_____ (2 marks)

- b. Sulfuric acid, H_2SO_4 , can be neutralised by potassium hydroxide solution. Write a balanced **ionic** chemical equation, **with states**, for the reaction between H_2SO_4 and potassium hydroxide solution.

_____ (2 marks)

- c. The reaction between lithium metal, $\text{Li}_{(\text{s})}$ and fluorine gas, $\text{F}_{2(\text{g})}$, to form $\text{LiF}_{(\text{aq})}$ is a redox reaction.

- i. Write the two half-equations, with states occurring during this process.

- ii. Identify the oxidant from part i.

Oxidant: _____

- iii. Write a balanced half equation for $\text{SO}_4^{2-}{}_{(\text{aq})} \rightarrow \text{SO}_{2(\text{g})}$ in acidic conditions.

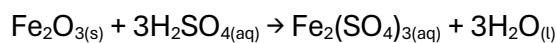
- iv. The reaction in part iii is: oxidation / reduction. **Circle** the correct term.

(6 marks)

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Question 3 (10 marks)

The chemical formula of rust is Fe_2O_3 . Rust can be removed from an iron object by washing the object with sulfuric acid. The reaction occurring is:



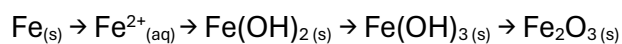
- a. The volume of 4.0 M H_2SO_4 required to remove all brown traces from a piece of iron piping is 7.30 mL. Calculate the mass of rust that reacted with the sulfuric acid.

(3 marks)

- b. 0.568 moles of sulfuric acid is available to try and remove 0.195 moles of rust from a child's bicycle. Which chemical is in excess in this reaction? You must show a calculation to prove this.

(2 marks)

In the formation of rust, the iron goes through the following stages.



- c. Complete the table to show the oxidation number of iron in each stage (5 marks)

Stage	A	B	C	D	E
Oxidation no. of iron					

Continue over the page

Question 4 (12 marks)

- a. The hydrogen sulfate ion, HSO_4^- , is amphiprotic (amphoteric). Write an equation to show hydrogen sulfate acting as a base. States are not required.

_____ (1 mark)

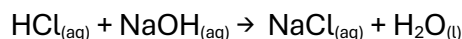
- b. What would be the chemical formula for the conjugate **acid** of water?

_____ (1 mark)

- c. Calculate the pH of a 0.02500M aqueous sulfuric acid solution.

(1 mark)

- d. The reaction between aqueous solutions of hydrochloric acid and sodium hydroxide can be represented by the chemical equation:



Some enthusiastic yr 11 chemistry students used titration to determine the concentration of HCl in a commercial cleaning product. The students took a 5.00 mL sample of the brick cleaner and carefully diluted it with deionised water in a 500.0 mL volumetric flask. 20.00 mL of this diluted HCl cleaner solution was pipetted into a conical flask. An average titre of 12.14 mL of a 0.187M aqueous sodium hydroxide solution was required to neutralise the diluted HCl solution.

- i) Calculate the number of mole of sodium hydroxide added to the diluted acid.

(1 mark)

- ii) Calculate the number of mole of diluted hydrochloric acid reacting with the hydroxide

Continue over the page

(1 mark)

iii) Calculate the concentration, in mol / L of hydrochloric acid in the **diluted** solution if the number of mole reacting with the hydroxide is 0.00310 mole.

(1 mark)

iv) Using your answer from part **iii**, Calculate the number of mole of hydrochloric acid in the 500.0mL volumetric flask.

(1 mark)

v) Using your answer from part **iv**, Calculate the molar concentration, of hydrochloric acid in the original brick cleaner sample.

(1 mark)

vi) How would your calculation of the original HCl concentration differ if the burette was rinsed with distilled water only? Explain.

(2 marks)

vii) What should be done in such an experiment to improve the precision of the results?

(1 mark)

viii) What dangerous goods label should be on the container of brick cleaner?

(1 mark)

Continue over the page

Question 5 (6 marks)

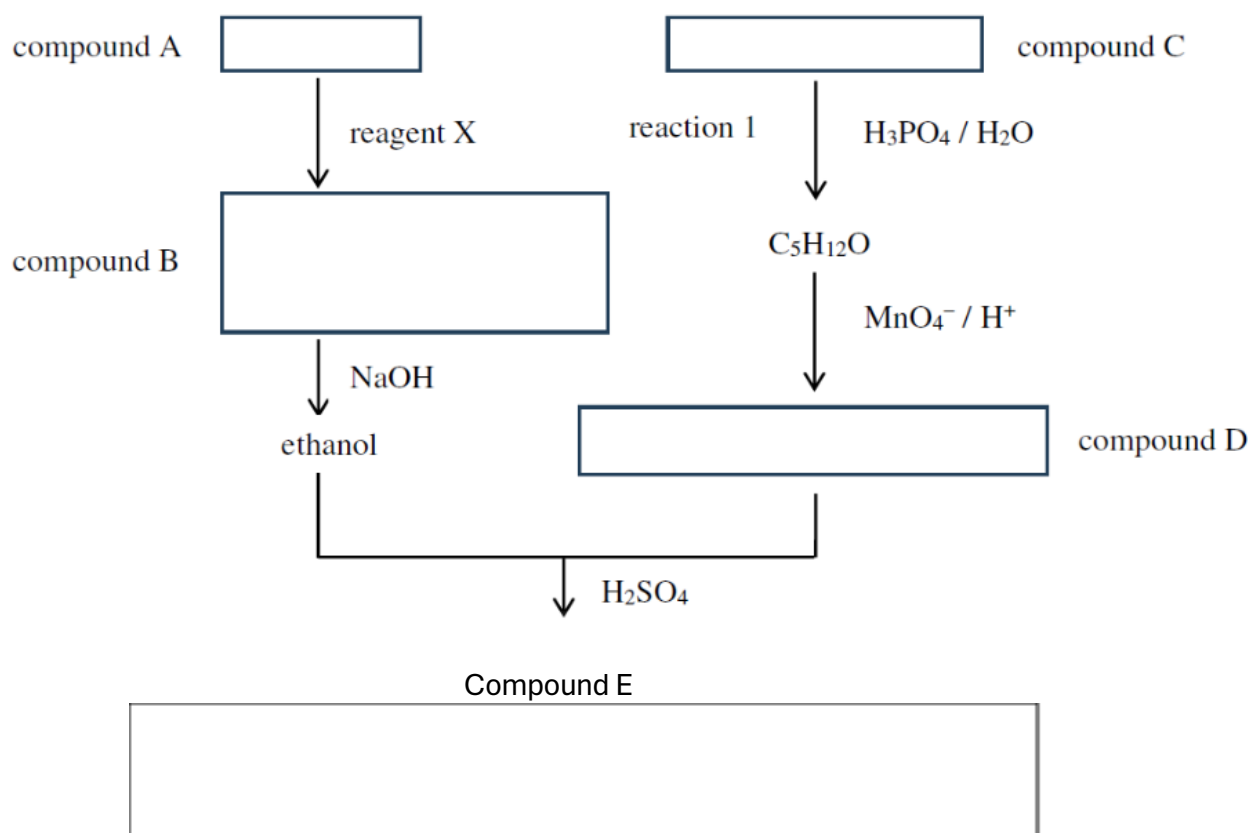
Complete the following table:

Name of compound		Formula of compound
		$\text{CH}_3\text{CH}_2\text{CH}_2\text{NH}_2$
		$\text{CH}_3\text{CH}_2\text{CH}(\text{CH}_3)\text{CH}_3$
		$\text{CH}_2\text{CHCH}_2\text{CH}_3$
2 – methylbutanoic acid		(Semi-structural formula required)
		$\text{CH}_3\text{CH}_2\text{CHBrCH}_3$
1,2,3-trichlorobut-1-ene	(full structural formula required)	

Continue over the page

Question 6 (10 marks)

Below is a reaction pathway used for the synthesis of a volatile organic compound that gives off a fruity aroma.



a. Identify reagent X _____

(1 mark)

b. In the appropriate boxes above, write the

- molecular formula for compound A.
- full structural formula for compound B.
- the systematic IUPAC name for compound D
- semi-structural formula for compound C
- skeletal structure for compound E.

(5 marks)

Continue over the page

- c. State what type of reaction is undertaken when producing the following.

Compound B: _____

Compound D: _____

Compound E: _____

(3 marks)

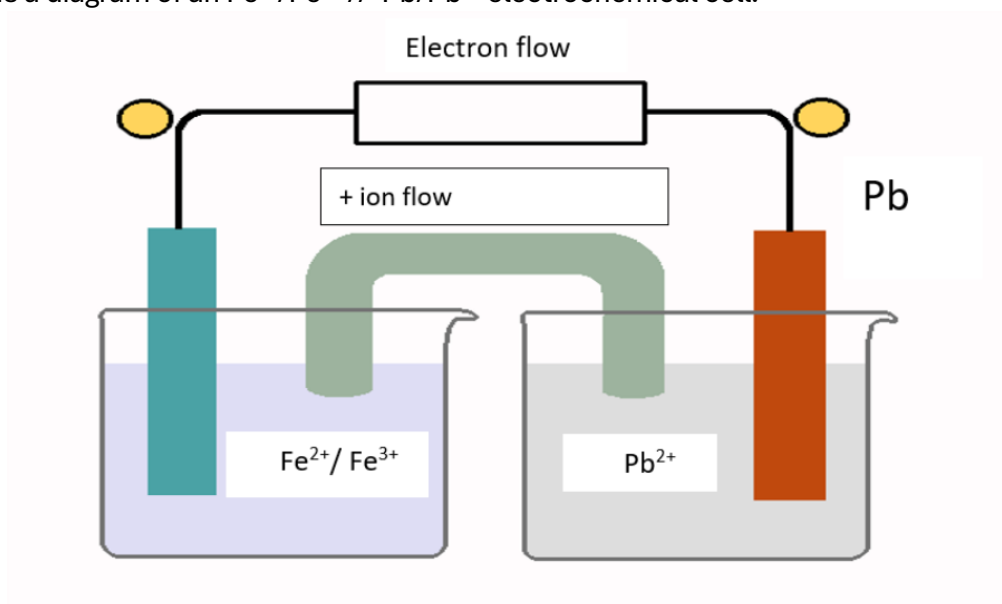
- d. Give the systematic IUPAC name for compound E

(1 mark)

Continue over the page

Question 7 (6 marks)

Below is a diagram of an $\text{Fe}^{2+}/\text{Fe}^{3+} // \text{Pb}/\text{Pb}^{2+}$ electrochemical cell.



- a. In the box on the diagram above, indicate the direction of the flow of positive ions through the salt bridge. (1 mark)
- b. In the box on the diagram, indicate the direction of the flow of electrons in the external circuit. (1 mark)
- c. Give a balanced half-equation for the reaction occurring at the **cathode**.

_____ (1 mark)

- d. What would be a suitable choice of material for the electrode on the left?

_____ (1 mark)

- e. This cell should produce an e.m.f of 0.90 V. In one set-up the e.m.f produced was only 0.35V. Give a possible reason for this discrepancy.

_____ (1 mark)

- f. Write the overall equation for the galvanic cell on the previous page. No states are required.

_____ (1 mark)

Continue over the page

Question 8 (6 marks)

It is argued that ethanol produced from the naturally occurring glucose polymer, cellulose, found in high amounts in corn and wood could be considered renewable compared to other fuels such as petroleum (petrol).

a. **i. Explain** why this is so.

(2 marks)

ii. Discuss one advantage **and** one disadvantage of using energy resources such as bioethanol.

(2 marks)

b. The cellulose found in corn and wood can be broken down into glucose. This glucose can then be fermented into ethanol by the following reaction



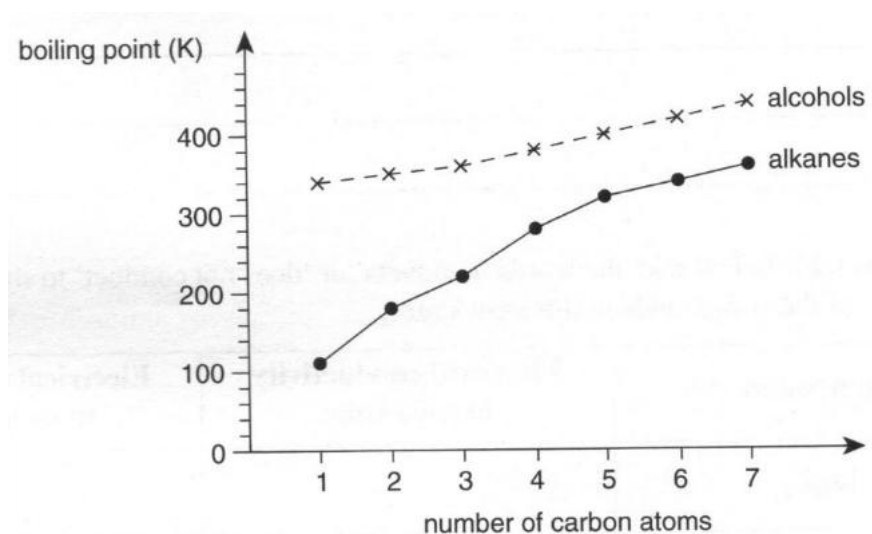
Explain how the production and use of ethanol using this method would help to fulfil the United Nations Sustainability goal 13.

(2 marks)

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Question 9 (2 marks)

The boiling points of the first seven alkanes and alcohols are shown in the graph:



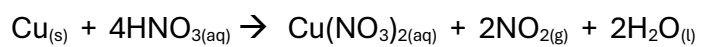
Comparing the boiling point of an alcohol with its corresponding alkane, why do alcohols boil at a higher temperature?

(2 marks)

Continue over the page

Question 10 (4 marks)

When concentrated nitric acid is added to copper metal, nitrogen dioxide gas is produced. The equation for the reaction is:



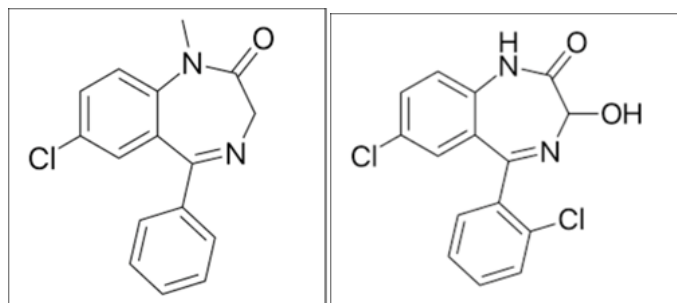
What volume of nitrogen dioxide will be produced at 105 kPa and 30.0°C if 80.0g of copper is consumed in the reaction? *Be sure your answer is to the correct number of significant figures.*

(4 marks)

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Question 11 (4 marks)

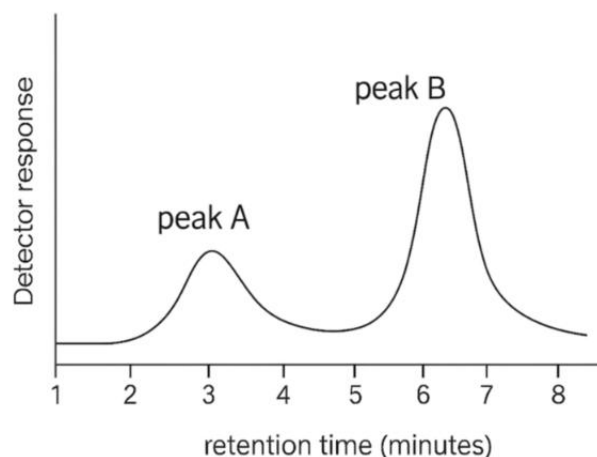
While working in a pharmaceutical quality-control laboratory, a chemist was asked to verify the identity and purity of a mixture containing two benzodiazepine medicines: diazepam and lorazepam. Both drugs are used to relieve anxiety but differ in their polarity and how long they act in the body.



Lorazepam

Diazepam

A small sample of the mixture was analysed using high performance liquid chromatography, which uses a non-polar stationary phase and a polar mobile phase. The chromatogram obtained is shown to the right →



a. **Determine** whether 'Peak A' represents lorazepam or diazepam. **Justify** your response using the chemistry theory you have studied this year.

(2 marks)

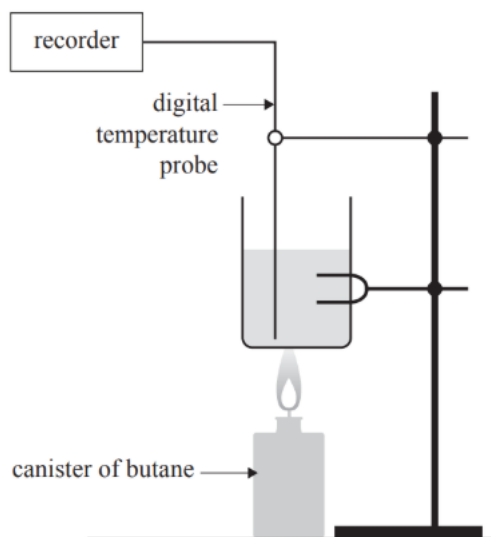
b. After the initial testing a pharmacist found a left over, unknown, sample. They were not sure whether the sample was lorazepam or diazepam. Using HPLC, describe how the pharmacist could determine which of the two medicines the unknown sample is?

(2 marks)

Continue over the page

Question 12 (8 marks)

A physical Chemist set out to determine how much energy in kJ can be produced from 1 mole of butane gas. She chose to use the set-up and procedure below.



1. Measure the initial mass of a butane canister.
2. Measure the mass of a metal can, add 250 mL of water and re-weigh.
3. Set up the apparatus as in the diagram and measure the initial temperature of the water.
4. Burn the butane gas for five minutes.
5. Immediately measure the final temperature of the water.
6. Measure the final mass of the butane canister when cool.

Results table from the experiment: →

Quantity	Measurement
mass of empty can	52.14 g
mass of can + water before combustion	303.37 g
mass of butane canister before heating	260.15 g
mass of butane canister after heating	259.79 g
initial temperature of water	22.1 °C
final temperature of water	32.7 °C

- a. Write a balanced chemical equation, with states, for the complete combustion of butane.

_____ (2 marks)

- b. Using the results table calculate the number of moles of butane gas burnt in the 5 minutes.

(2 marks)

Continue over the page

c. Using the results table on the previous page, calculate the energy absorbed by the water in kilojoules (KJ).

(2 marks)

d. Use your answers to **b.** and **c.** to calculate the energy content of butane per mol in kJ / mol.

(1 mark)

e. What could the Chemist do to improve the level of accuracy of the experiment?

(1 mark)

****End of Examination****

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