Year 11 Semester Two Examination, 2015

QUESTIONS

CHEMISTRY

Section One: Multiple-choice **25% (25 Marks)**

This section has **25** questions. Answer **all** questions on the separate Multiple-choice Answer Sheet provided. For each question shade the box to indicate your answer. Use only a blue or black pen to shade the boxes. If you make a mistake, place a cross through that square, do not erase or use correction fluid, and shade your new answer. Marks will not be deducted for incorrect answers. No marks will be given if more than one answer is completed for any question.

Suggested working time: 50 minutes.

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1. Which of the following correctly represents the electron configuration of a sulfur atom in its ground (lowest energy) state?

   (a) 2,6,6,2
   (b) 2,8,6
   (c) 2,14
   (d) 2,6

2. Which of the pairs of elements below will form polar covalent bonds?

   (a) Oxygen and hydrogen
   (b) Sodium and chlorine
   (c) Chlorine and chlorine
   (d) Magnesium and sulfur

3. Which of the following statements best describes why the atomic radius of atoms decreases across period 2 of the periodic table from lithium to neon?

   (a) The number of neutrons in the nucleus of the atoms decreases.
   (b) The number of protons in the nucleus of the atoms increases.
   (c) The number of valance electrons increases.
   (d) The number of energy levels decreases.

4. In an atomic absorption spectrum, the black lines in the spectrum are caused by

   (a) electrons gaining energy as they leave the atom.
   (b) electrons releasing energy as they move from one energy level to another.
   (c) electrons reflecting light at a particular wavelength.
   (d) electrons being promoted from a lower energy level to a higher energy level.

5. Which of the following describes the processes occurring in a mass spectrometer in the correct order from first to last?

   (a) vaporisation acceleration deflection ionisation detection
   (b) ionisation vaporisation acceleration deflection detection
   (c) vaporisation ionisation acceleration deflection detection
   (d) acceleration Ionisation deflection vaporisation detection

6. Which of the following species is **not** planar?

   (a) H_2CO
   (b) CO_3^{2-}
   (c) PH_3
   (d) $BeCl_3$

7. Which of the following contains polar-covalent bonds but is a non-polar molecule?

   (a) CO_2
   (b) $C\ell_2$
   (c) H_2O
   (d) HCN

8. Nanoparticles are particles that have a size between 1 – 100 nm. (where 1 nm (nanometre) = 1×10^{-9} m). Which of the statements below best explains why nanoparticles have properties different from substances that contain larger particles?

   (a) Nanoparticles are always electrically charged.
   (b) Nanoparticles have a larger surface/volume ration than larger particles.
   (c) Nanoparticles are smaller than atoms or molecules.
   (d) Nanoparticles contain electrons in excited states which makes them more reactive.

9. Crude oil is separated into usable fractions, such as petrol, diesel and lubrication oil in an oil refinery. The crude oil is heated, the vapour produced rises up a tower, cools and condenses at different points in the tower.

   This separation technique relies on the fact that the fractions of the crude oil have different

   (a) solubilities.
   (b) reactivity's.
   (c) densities.
   (d) boiling points.

10. Which of the following substances exhibits hydrogen bonding?

    (a) HF
    (b) H_2S
    (c) H_2
    (d) CH_4

11. Which of the following substances is **not** an alkene?

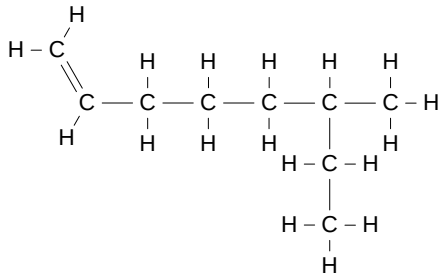
    (a) $CH_3C(CH_3)C(CH_3)CH_2CH_3$
    (b) $CH_3CH(CH_3)CH(CH_3)CHCHCH_3$
    (c) $CH_3CH(CH_3)CH(CH_3)CH_2CH_3$
    (d) $CH_3CH_2C(CH_3)_2CHCH_2$

12. Which of the following would conduct an electric current?

i an aqueous solution of potassium bromide
ii liquid bromine
iii solid silver bromide
iv solid potassium

(a) i and ii only
(b) i and iv only
(c) ii and iv only
(d) i, ii and iv only.

13. Which of the following is the correct name for this organic compound?



(a) 3-methyloct-2-ene
(b) *cis*-2-ethylhept-1-ene
(c) 6-methyloct-1-ene
(d) 2-ethylhept-5-ene

14. Water supplies can be contaminated by the presence of heavy metals. Which of the elements below is **not** considered a heavy metal containment?

(a) Aluminium
(b) Cadmium
(c) Mercury
(d) Lead

15. Which of the following (all at STP) will contain the most atoms?

(a) 454 L of helium gas
(b) 80.00 g of argon gas
(c) 454 L of argon gas
(d) 80.00 g of helium gas

16. Which of the following correctly lists the products of the reaction of dilute sulfuric acid and sodium hydrogencarbonate?

(a)	sodium nitride	carbon dioxide	
(b)	carbon dioxide	water	sodium hydrogensulfate
(c)	water	carbon dioxide	sodium sulfate
(d)	sodium carbonate	carbon dioxide	water

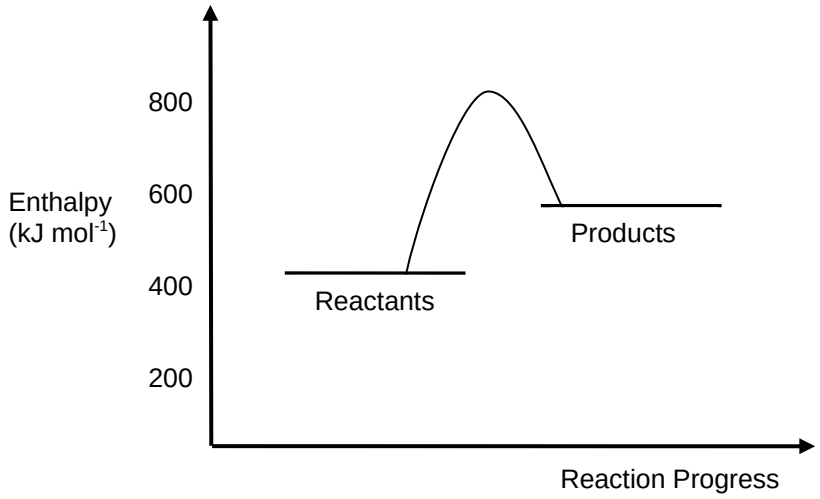
17. Which of the following is the correct equation for the complete combustion of octane?

(a) $2\ C_8H_{18} + 17\ O_2 \rightarrow 16\ CO + 18\ H_2O$
(b) $C_3H_8 + 5\ O_2 \rightarrow 3\ CO_2 + 4\ H_2O$
(c) $2\ C_8H_{18} + 9\ O_2 \rightarrow 16\ C + 18\ H_2O$
(d) $2\ C_8H_{18} + 25\ O_2 \rightarrow 16\ CO_2 + 18\ H_2O$

18. Which of the following best explains why chemical reactions speed up when the temperature is increased?

(a) Most reactions are endothermic so heat is always required to start a reaction.
(b) A higher proportion of particles will collide with sufficient energy.
(c) Catalysts require high temperatures to be effective.
(d) Higher temperature causes the activation energy of the reaction to reduce.

19. An energy profile diagram for a chemical reaction is shown below.



Estimate the activation energy for this reaction.

(a) 400 kJ mol^{-1}
(b) 180 kJ mol^{-1}
(c) 240 kJ mol^{-1}
(d) 800 kJ mol^{-1}

20. A number of aerosol canisters were disposed of in a landfill facility and left out in the hot sun. As the canisters heated up, which of the statements below describe what would be happening with the gas remaining in the can?

    i The kinetic energy of all the particles in the canisters would be increasing.
    ii There would be more collisions between the particles of the gas and the inside of the container.
    iii The mass of the gas inside the container would increase.
    iv There would be more collisions between the particles of the gas and other particles in the canister.

    (a) I, ii and iv only
    (b) ii and iv only
    (c) ii and iii only
    (d) I, ii and iv only

21. Ethanoic (acetic) acid is the main acidic constituent in vinegar. What would be the approximate pH value for a 0.10 mol L^{-1} solution of ethanoic (acetic) acid?

    (a) 1
    (b) 5
    (c) 7
    (d) 9

22. In order to identify an unknown solution **A**, a few drops of the solution was added separately to two test tubes:

    - a test tube containing solution of dilute hydrochloric acid, and
    - a test tube containing dilute sodium hydroxide solution.

    In both test tubes there was no visible reaction.

    Which of the following could be solution **A**?

    (a) $Na_2CO_3(aq)$
    (b) $CuSO_4(aq)$
    (c) $BaCl_2(aq)$
    (d) $AgNO_3(aq)$

23. Which of the following processes is endothermic?

    (a) freezing of water
    (b) the combustion of methane
    (c) petrol vapour forming from liquid petrol
    (d) sodium chloride crystals forming in water

24. Approximately 80 g of solid copper sulfate is added to water in a beaker and stirred. When the mixture settles, it has become a clear blue liquid with some blue crystals at the bottom of the beaker. Which of the following statements is true?

    (a) The clear liquid is a saturated solution.
    (b) Adding more copper sulfate crystals will make the blue colour deeper.
    (c) The beaker contains a homogeneous mixture.
    (d) Adding more water will increase the concentration of the solution as more solid will dissolve.

25. A substance melts at 1 085 °C, it is a salmon pink colour and is a good electrical conductor in the solid and liquid state. The structure of this substance is most likely to be

    (a) a molecular network.
    (b) metallic bonding.
    (c) an ionic lattice.
    (d) covalent molecular.

End of Section One

Section Two: Short answer **35% (70 Marks)**

This section has **11** questions. Answer **all** questions. Write your answers in the spaces provided.

When calculating numerical answers, show your working or reasoning clearly. Express numerical answers to the appropriate number of significant figures and include appropriate units where applicable.

Question 26 **(6 marks)**

Write ionic equations, including state symbols, for any reactions that occur in the following situations.

(a) Dilute sulfuric acid solution is added to aluminium metal. (3 marks)

(b) Solid magnesium oxide is added to dilute nitric acid. (3 marks)

Question 27 **(4 marks)**

For each of the following reactions, describe expected observations, including any

- Colours
- Odours
- Precipitates (give the colour)
- Gases evolved (give the colour or describe as colourless)

(a) Solid copper(II) carbonate is added to dilute sulfuric acid to produce copper(II) sulfate, carbon dioxide and water. (2 marks)

(b) $FeC\ell_2(aq) + AgNO_3(aq) \rightarrow 2\ AgC\ell(s) + Fe(NO_3)_2(aq)$ (2 marks)

Question 28 **(4 marks)**

Classify the following 8 substances

Cu	**CuS**	**CaH_2**	**Hg**
$NH_4C\ell$	**H_2SO_4**	**SiO_2**	**$SiC\ell_4$**

as metals, ionic compounds, covalent network substances and covalent molecular substances by completing the table below

Metals	Ionic compounds	Covalent network substances	Covalent molecular substances

Question 29 **(8 marks)**

The maximum acceptable level of lead in Australian drinking water is 0.01 mg per litre. Dissolved lead is normally found in the in the form of Pb^{2+} ions.

(a) State why the level of heavy metals such as lead needs to maintained at relatively low levels in drinking water. (2 marks)

(b) Assuming that 1.00 litre of water weighs 1.00 kg, calculate this concentration of lead in:

(i) parts per million (ppm) (1 marks)

(i) moles per litre (mol L^{-1}) (3 marks)

(c) It was suggested that the lead could be removed from drinking water by a precipitation reaction.

(i) Write the name or formula of a solution that could be added to the drinking water to remove the dissolved lead. (1 mark)

(ii) Write an ionic equation to show the reaction that would occur with the solution suggested in Part © (ii) above. (1 mark)

Question 30 **(6 marks)**

A student was using the neutralisation of copper(II) oxide to produce copper(II) chloride. He added an excess amount of the copper(II) oxide to 45.0 mL of 1.50 mol L^{-1} hydrochloric acid.

(a) Calculate the maximum mass of copper(II) chloride that he could produce from this volume of acid. (3 marks)

(b) Outline a step-by-step method that he would use to produce solid crystals of the copper(II) chloride. (3 marks)

Question 31 **(6 marks)**

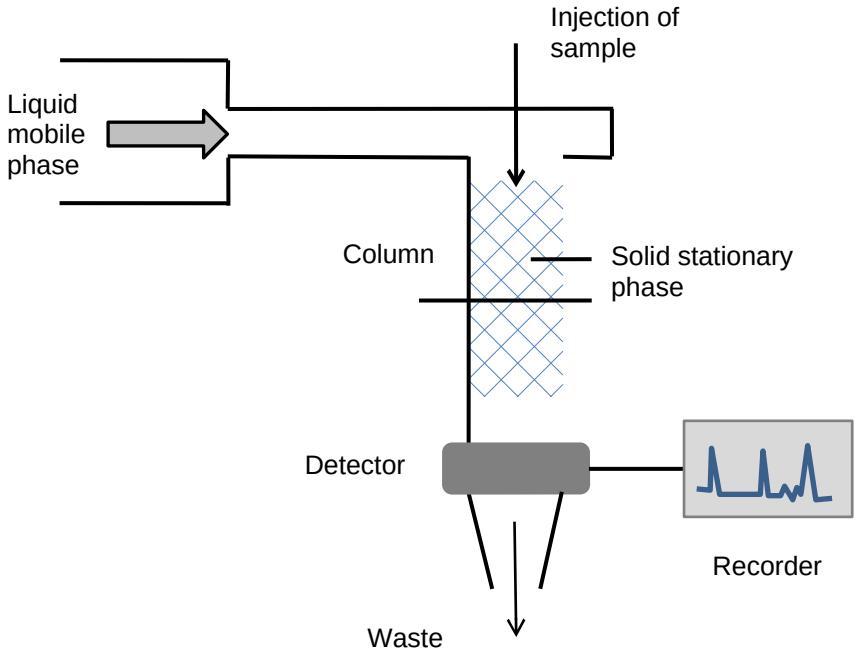
For each molecule listed in the table below draw the structural formula, representing **all** valence shell electron pairs as : or as — and indicate the shape of the species by a sketch or a name.

Species	**Electron Dot Diagram (Lewis diagram)**	**Shape (sketch or name)**
Hydrogen sulfide, H_2S		
Methane, CH_4		
Ethene, C_2H_4		

Question 32 **(8 marks)**

The diagram below shows the main stages of a High Performance Liquid Chromatography (HPLC) apparatus.

High Performance Liquid Chromatography



(a) Explain the role of the:

(i) liquid mobile phase (2 marks)

(ii) solid stationary phase (1 mark)

(b) The printout from the recorder has **absorbance** on the y (vertical) axis. Name the variable that will be on the X (horizontal) axis. (1 mark)

© Thin Layer Chromatography (TLC) also uses a liquid mobile phase and a solid stationary phase. Complete the table to show two key differences between TLC and HPLC. (4 marks)

	TLC	**HPLC**
Description of the movement of the mobile phase.		
How components of the mixture are distinguished from each other.		

Question 33 **(6 marks)**

Use your knowledge of the kinetic theory and/or intermolecular forces to explain the following situations.

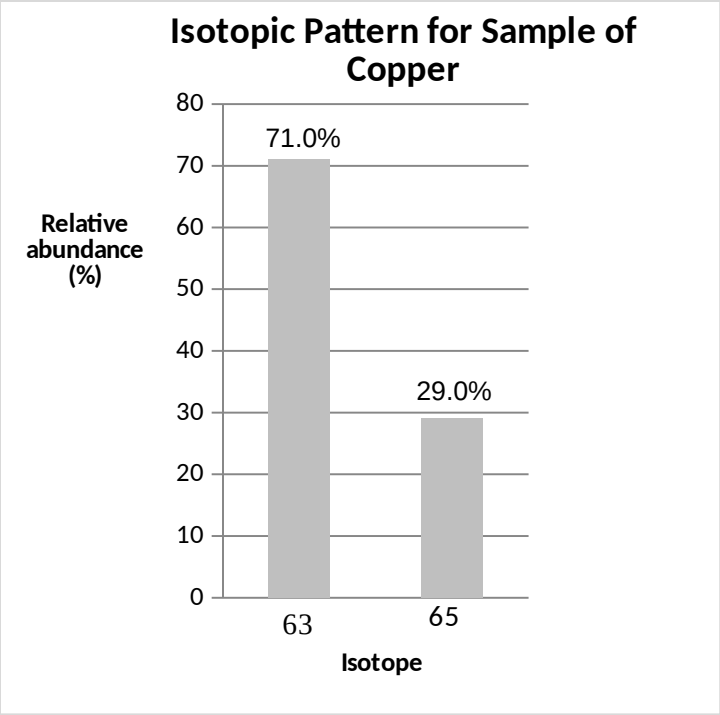
(a) The pressure inside a car tyre will increase on a hot day. (3 marks)

(b) The vapour pressure of water reduces when the temperature reduces. (3 marks)

Question 34 **(8 marks)**

A sample of copper was analysed using a mass spectrometer to identify the isotopic composition of the copper. In the process, copper ions with relative atomic masses of 63 and 65 where identified.

The following results were obtained.



(a) Explain briefly how the mass spectrometer is able to separate the ions of two different isomers of copper (3 marks)

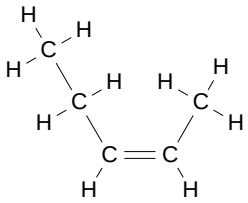
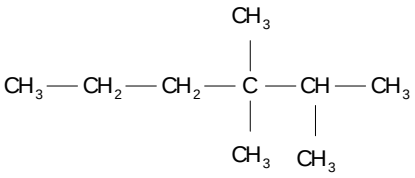
(b) Calculate the number of neutrons in the nucleus of a copper-65 atom. (1 mark)

(c) From the data above, calculate the relative atomic mass (atomic weight) of this sample of copper. (2 marks)

(d) Compare your result from (c) to the standard atomic weight given on the Chemistry Data Sheet. Suggest a reason (not including experimental error) for any difference. (2 marks)

Question 35 **(4 marks)**

Complete the following table showing the structure and names of four hydrocarbons.

Structure	IUPAC Name
	Butane
	
	
	ethylpentane

Question 36 **(10 marks)**

When magnesium burns in oxygen, a very bright white flame is produced and the white solid, magnesium oxide, is formed.

Complete the following table comparing the properties of magnesium and magnesium oxide by describing any similarities or differences, and then explaining these in terms of the bonding present in the two substances.

Marks should be awarded where labelled diagrams are used in place of the explanatory text

Description				
	Magnesium	**Marks**	**Magnesium Oxide**	**Marks**
Hardness	Malleable / ductile	1	Hard / brittle	1
Explanation		1		1
		1		1
Electrical Conductivity when molten		1		1
Explanation		1		1
	Total	**5**	**Total**	**5**

End of Section Two

Section Three: Extended answer **40% (80 Marks)**

Where questions require an explanation and/or description, marks are awarded for the relevant chemical content and also for coherence and clarity of expression. Lists or dot points are unlikely to gain full marks.

Final answers to calculations should be expressed to the appropriate number of significant figures.

Question 37 **(22 marks)**

A student carried out a series of experiments to investigate the effect of temperature on the rate of a chemical reaction. The reaction she used was dilute hydrochloric acid reacting with magnesium ribbon. She measured the rate of the reaction by measuring the time it took to produce 20 mL of hydrogen gas. The results of the experiments are shown below.

Mass of magnesium ribbon (g)	Volume of dilute HCℓ (mL)	Temperature of hydrochloric acid (°C)	Time taken to produce 20 mL of H_2 gas (s)	Rate of reaction (1/time) (s^{-1})
5.0	40	20	97	0.010
5.0	40	29	50	0.020
5.0	40	39	24	0.042
5.0	40	47	13	0.077
5.0	40	56	7	0.143

(a) For this experiment, name

(i) the independent variable. (1 mark)

(ii) **one** controlled variable (other than volume of HCℓ and mass of Mg, and the volume of gas produced). (1 mark)

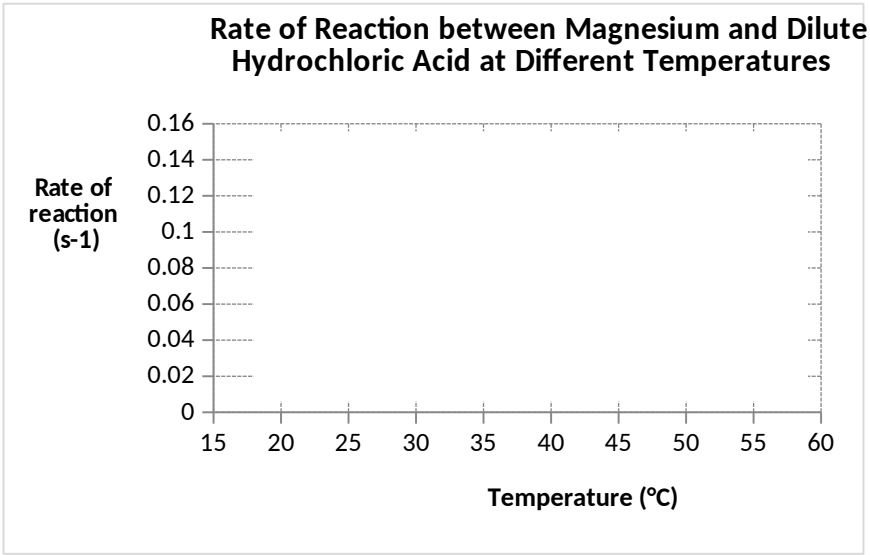
(b) Draw a labelled diagram of the apparatus that the student could have used to collect this data. (3 marks)

I With reference to the equipment shown above, state:

(i) one possible source of **random** error in the experiment. (1 mark)

(ii) one possible source of **systematic** error in the experiment. (1 mark)

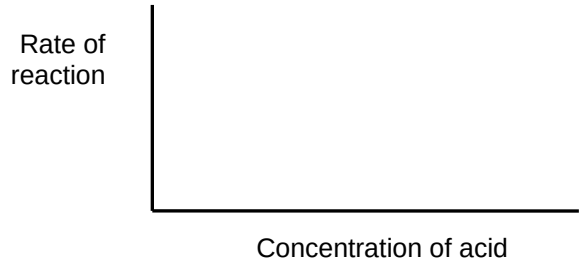
(d) On the grid below, draw a line graph showing the rate of the reaction against the temperature. (5 marks)



(e) Use your graph to predict the **rate** of the reaction at 50 °C. (1 mark)

(f) Using the collision theory, and including an appropriate diagram, explain how temperature affects the rate of a chemical reaction. (4 marks)

(g) The student then carried out another experiment using the magnesium and hydrochloric acid to investigate the effect of **concentration** on the rate of the reaction. On the axis below, **sketch** the graph that she would expect to obtain. (2 marks)



(h) Using collision theory, briefly explain any differences in the overall shape of the graphs in part (d) (temperature) and part (g) (concentration). (3 marks)

Question 38 **(13 marks)**

This question is about the properties of water

(a) In cold climates, bodies of water such as ponds and lakes can freeze. The ice floats on the top of water because it is less dense than the liquid water. This allows the aquatic life in the water to survive during the colder months.

Describe, using a diagram, intermolecular bonding in solid ice and explain why the volume of the water increases (and the density reduces) when it changes from liquid water to solid ice. (5 marks)

(b) In cold climate wineries such as in Tasmania, during the winter the grape vines are sprayed with water to protect them from frost damage.

The sprayed water freezes on the vines. This process can be shown as:

$$H_2O(\ell) \rightarrow H_2O(s)$$

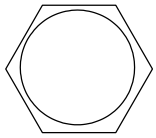
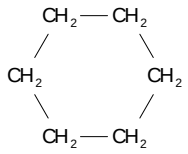
Consider the enthalpy change and by referring to intermolecular bonding explain why this process prevents the vines from freezing. (4 marks)

(c) Water is the most commonly used solvent, but it cannot dissolve hydrocarbons such as oil, petrol and grease.

Explain, using your knowledge of intermolecular bonding why water is **unable** to dissolve these types of substances.

(4 marks)

Question 39 **(20 marks)**

Benzene (C_6H_6)  can be converted to cyclohexane (C_6H_{12}) 

by the addition of hydrogen. The reaction can be catalysed using metallic nanoparticles.

(a) Using an appropriate diagram, explain how a catalyst can speed up the rate of the chemical reaction. (4 marks)

(b) Using collision theory, explain why the metal catalyst is more effective in the form of nanoparticles than in the bulk form (larger pieces) of the metal. (2 marks)

(c) Write a balanced chemical equation for this reaction. (1 mark)

(d) Calculate the mass of cyclohexane that can be produced from 750 g of benzene. (3 marks)

(e) (i) Calculate the mass of hydrogen that would be required for this reaction. (2 marks)

(ii) Calculate the volume of this amount of hydrogen gas at standard temperature and pressure (STP). (2 marks)

(f) During this process, the chemical engineer was concerned that cyclohexene (C_6H_{10}) might be formed in place of the cyclohexane.

(i) Describe a chemical test, including expected observations, that would detect the presence of cyclohexene in the products of this reaction. (2 marks)

(ii) With reference to the equation in part (c), suggest how the chemical engineer can reduce the risk of cyclohexene being formed in the reaction. (1 mark)

(g) The percentage by mass of carbon in cyclohexane is 85.8%

(i) Calculate the percentage by mass of carbon in benzene (1 mark)

(ii) Use you answer to (g) (i) to suggest why aromatic substances such as benzene burn with a more smoky flame than aliphatic compounds such as cyclohexane. (2 marks)

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Question 40 **(25 marks)**

When camping, a range of portable stoves can be used for cooking. Pictured below are a gas stove that burns butane, C_4H_{10}, which is stored in a pressurised container and a *Trangia* Stove, which burns methylated spirits (mainly ethanol, C_2H_5OH) as its fuel. .

Butane camp stove

Trangia stove

The properties of the two fuels are shown in the table below.

	Butane	**Ethanol**
Formula	C_4H_{10}	C_2H_5OH
Molecular weight	58.12	46.068
Boiling point	- 0.5 °C	78.4 °C
Equation for combustion	$2\ C_4H_{10} + 13\ O_2 \rightarrow 8\ CO_2 + 10\ H_2O$	$C_2H_5OH + 3\ O_2 \rightarrow 2\ CO_2 + 3\ H_2O$
Enthalpy of combustion	2859 kJ mol^{-1}	1367 kJ mol^{-1}

(a) The butane canister contains 220 g (2.20×10^2 g) of butane. Calculate the number of moles of butane in one canister. (1 mark)

(b) Calculate the maximum amount of energy that could be released from this amount of butane. (2 marks)

I One canister of butane will operate the stove for 60 minutes.

(i) Calculate the volume of oxygen (in mL) required **per second**, assuming standard temperature and pressure (STP). (4 marks)

(ii) If the oxygen is not supplied at the rate calculated in (d) part (ii), butane will undergo incomplete combustion to produce carbon monoxide, a toxic gas. Write an equation for the incomplete combustion of butane. (1 mark)

(iii) The camper used the stove inside his tent with a limited supply of oxygen to the stove. Give two reasons why this is extremely dangerous. (2 marks)

(d) A camping magazine was producing an article about camp cooking and you have been asked to provide information to inform to this article - using your scientific knowledge to compare the two stoves.

Using the headings given below, **compare** the fuels used in the two stoves. You should include relevant diagrams, equations, and calculations to **explain** your ideas.

The information about the fuels is included again below:

	Butane	**Ethanol**
Formula	C_4H_{10}	C_2H_5OH
Molecular weight	58.12	46.068
Boiling point	- 0.5 °C	78.4 °C
Enthalpy of combustion	2859 kJ mol^{-1}	1367 kJ mol^{-1}
Equation for combustion	$2\ C_4H_{10} + 13\ O_2 \rightarrow 8\ CO_2 + 10\ H_2O$	$C_2H_5OH + 3\ O_2 \rightarrow 2\ CO_2 + 3\ H_2O$

Safety (Compare how safe each fuel is to store) (2 marks)

Energy output (Compare the amount of energy released per 100 g of each fuel) (4 marks)

Carbon emissions (Compare the volume (at STP) of carbon dioxide released to the atmosphere for every 100 g of each fuel) (5 marks)

Sustainability (compare the renewability of each fuel) (2 marks)

Recommendation (Overall summary and recommendation of which fuel to use) (2 marks)