Name: ....

Teacher: ....

Reading time before commencing work: **Ten (10) minutes**

Materials required/recommended for this paper

To be provided by the supervisor

This Question/Answer Booklet
Separate Multiple Choice Answer Sheet
Separate Chemistry Data Sheet

To be provided by the candidate

Standard Items: Pens, pencils, eraser or correction fluid and ruler

Special Items: Calculators satisfying the conditions set by the Curriculum Council.

Important note to candidates

No other items may be taken into the examination room. It is your responsibility to ensure that you do not have any unauthorised notes or other items of a non-personal nature in the examination room. If you have any unauthorised material with you, hand it to the supervisor **before** reading any further.

Instructions to candidates

Reading Time: The examiners recommend that candidates spend the reading time mainly reading the Instructions to Candidates and Parts 2, 3 and 4.

Structure of the 3 hour paper

Part	Format	Questions set	Questions to be attempted	Marks allocated	Suggested time	Student mark	Mark conversion
1	Multiple Choice	30	All	60	50		/30
2	Short Answer	11	All	70	60		/35
3	Calculations	4	All	50	50		/25
4	Extended Answer	2	Any one	20	20		/10
			TOTAL	200	180		/100

Part 1
Use a 2B, B or HB pencil, on the separate Multiple Choice Answer Sheet. Do **not** use a ball point or ink pen.
If you consider that two or more of the alternative responses are correct, choose the one you think is best. If you think you know an answer, mark it even if you are not certain you are correct. Marks will not be deducted for incorrect answers.
Feel free to write or do working on the question paper; many students who score high marks in the Multiple Choice Section do this.

Parts 2, 3 and 4
Use a ball point or ink pen. **Do not** answer in pencil. Write your answers in the Question/Answer Booklet. At the end of the examination make sure that your name is written on your Question/Answer Booklet and on your separate Multiple Choice Answer Sheet.

Chemical equations
For full marks, chemical equations should refer only to those species consumed in the reaction and the new species produced. These species may be **ions** [for example Ag^+ (aq)], **molecules** [for example NH_3(g), NH_3(aq), CH_3COOH(l), CH_3COOH(aq)] or **solids** [for example $BaSO_4$(s), Cu(s), Na_2CO_3(s)].

PART 1:Multiple Choice Section (Various marks - 30% of the paper)
Answer **ALL** questions in Part 1 on the Separate Multiple Choice Answer Sheet provided.
Each question in this section is worth 2 marks.

1.   Which of the following are the sub-atomic particles that exist outside the nucleus of an atom?

   (a)   Electrons only.

   (b)   Protons only.

   (c)   Neutrons only.

   (d)   Protons and neutrons.

2.   Which of the following lists clearly demonstrates three different isotopes for the respective element?

   (a) ^{32}S, ^{33}S, ^{34}S

   (b)   Cl, Cl⁻, Cl_2

   (c)   C, CO, CO_2

   (d)   Sn, Sn^{2+}, Sn^{4+}

3.   In the negatively charged chloride ion $^{36}_{17}Cl^-$,   the numbers of protons, neutrons and electrons are respectively:

   (a)   17, 17, 16

   (b)   17, 19, 18

   (c)   17, 36, 18

   (d)   16, 37, 16

4.   The electronic configuration of a neutral atom is 2,4. Which of the following elements is in the same group as this neutral atom?

   (a)   Nitrogen

   (b)   Magnesium

   (c)   Silicon

   (d)   Sulfur

5.   A solution of barium hydroxide contains which of the following?

   (a)   An equal number of barium and hydroxide ions.

   (b)   Twice as many barium ions as hydroxide ions.

   (c)   Twice as many hydroxide ions as barium ions.

   (d)   Molecules of barium hydroxide (because most hydroxides are insoluble).

6.   How many oxygen atoms are present in 183.13 grams of $C_6H_5N_3O_4$?

   (a)   4

   (b)   40

   (c) 6.02×10^{23}

   (d) $4.0 \times 6.02 \times 10^{23}$

7.   A chemist analyses the percentage composition by mass of these five hydrocarbons:
     CH_4, C_2H_4, C_4H_{10}, C_6H_6, C_6H_{14}
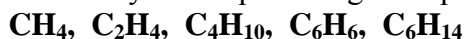
   Which of the following lists the substances in order of increasing percentage composition of hydrogen?

   (a) CH_4, C_4H_{10}, C_6H_{14}, C_2H_4, C_6H_6

   (b) CH_4, C_2H_4, C_4H_{10}, C_6H_6, C_6H_{14}

   (c) C_6H_6, C_2H_4, C_6H_{14}, C_4H_{10}, CH_4

   (d) C_6H_{14}, C_6H_6, C_4H_{10}, C_2H_4, CH_4

8.   An atom has the following successive ionisation energy values:
     584 kJ mol^{-1}, 1823 kJ mol^{-1}, 2751 kJ mol^{-1}, 11584 kJ mol^{-1}, 14837 kJ mol^{-1}
     Which of the following could the atom be?
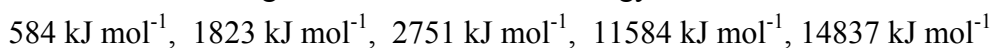
   (a)   Sodium

   (b)   Aluminium

   (c)   Phosphorus

   (d)   Argon

9.   0.1 moles of each of the following compounds is added separately to 1000 mL of water and stirred vigorously. In which cases would a heterogeneous mixture form?

        1. NaCl   2. $PbSO_4$ 3. H_2SO_4 4. NaOH

   (a)   2 only

   (b)   4 only

   (c)   3 and 4 only

   (d)   1, 2 and 3 only

SEE NEXT PAGE

10. Which of the following is not true for bromine?

  (a) It is a coloured element.

  (b) It is less reactive than chlorine.

  (c) It does not react with other non-metals.

  (d) It can form ionic salts with metals.

11. Which of the following substances is composed of positive and negative ions?

  (a) $Al(s)$.

  (b) $H_2O(l)$.

  (c) $HCl(g)$.

  (d) $MgO(s)$.

12. The table below shows the boiling points of gases that occur in the atmosphere

Gas	Boiling Point (^oC)
Argon	-186
Carbon dioxide	-78 (sublimes)
Nitrogen	-196
Oxygen	-183
Water vapour	100

  If air was condensed to a liquid and allowed to warm up slowly in what order would the components of the mixture boil away?

  (a) Argon, carbon dioxide, nitrogen, oxygen, water vapour.

  (b) Nitrogen, argon, oxygen, carbon dioxide, water vapour.

  (c) Water vapour, carbon dioxide, oxygen, argon, nitrogen.

  (d) Carbon dioxide, oxygen, argon, nitrogen, water vapour.

13. Which of the following statements is false?

  (a) A variation in atmospheric pressure will result in a change of boiling point for a substance.

  (b) At a particular temperature all the molecules in a liquid have the same kinetic energy.

  (c) The temperature of a liquid falls as evaporation takes place.

  (d) Molecules that escape into the gaseous state behave in the same manner as molecules in normal gases.

14. According to reaction rate theory, what are the prerequisites for any successful collision?

   (a) The reaction must be exothermic or endothermic.

   (b) Reacting particles must collide with kinetic energy and potential energy.

   (c) It must have a low activation energy barrier and a heat of reaction.

   (d) Reacting particles must collide with an appropriate orientation and with sufficient energy.

15. Which of the following lists correctly identifies a strong acid, a weak acid, a strong base and a weak base respectively?

   (a) H_3PO_4, CH_3COOH, NaOH, ammonia.

   (b) H_2SO_4, H_3PO_4, KOH, $Ca(OH)_2$.

   (c) HNO_3, gastric juice, vinegar, ammonium ion.

   (d) HCl, citric acid, $Ca(OH)_2$, Na_2CO_3.

16. The conjugate base of the ion HCO_3^- is which of the following?

   (a) CO_3^{2-}

   (b) H_2CO_3

   (c) OH^-

   (d) H_2O

17. Which of the following completes the table correctly?

	Monoprotic acid	Dilute acid	Amphoteric hydroxide
(a)	NH_4^+	0.1 mol L^{-1} H_2SO_4	$Cr(OH)_3$
(b)	HCl	6 mol L^{-1} CH_3COOH	Al
(c)	H_2SO_4	0.01 mol L^{-1} HCl	NH_4OH
(d)	CH_3COOH	6 mol L^{-1} HCl	$Zn(OH)_2$

18. The overall equation for photosynthesis is: $6CO_2(g) + 6H_2O(g) \rightarrow C_6H_{12}O_6(s) + 6O_2(g)$

Which of the following identifies the reducing agent in this reaction?

   (a) C in CO_2.

   (b) H in H_2O.

   (c) O in CO_2 and/or H_2O.

   (d) $O_2(g)$.

19. What is the empirical formula for the aromatic hydrocarbon benzene?

    (a) C_6H_6

    (b) C_3H_3

    (c) C_2H_2

    (d) CH

20. What is the most likely organic product when bromine is reacted with propene?

    (a) 1-bromopropane

    (b) 2-bromopropane

    (c) 1,1-dibromopropane

    (d) 1,2-dibromopropane

21. Choose the correct statement about the redox reaction below:

    $$2Al(s) + 3Cu^{2+}(aq) \rightarrow 2Al^{3+}(aq) + 3Cu(s)$$

    (a) Cu(s) is the oxidising agent.

    (b) Al atoms gain electrons.

    (c) The oxidation number of the $Cu^{2+}(aq)$ has increased.

    (d) Al(s) is the reducing agent.

22. Which of the following equations best demonstrates what happens in the "pop" test?

    (a) $H + O \rightarrow H_2O(l)$

    (b) $H_2(g) + O_2(g) \rightarrow H_2O(l)$

    (c) $2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$

    (d) $4H^+(g) + O_2(g) \rightarrow 2H_2O(l)$

23. Which of the following lists the compounds in order from highest to lowest electrical conductivity when in 1.0 mol L^{-1} aqueous solution?

    (a) $(NH_4)_2SO_4$, NaCl, NH_3, glucose

    (b) NaCl, glucose, NH_3, $(NH_4)_2SO_4$

    (c) $(NH_4)_2SO_4$, NH_3, NaCl, glucose

    (d) NaCl, $(NH_4)_2SO_4$, NH_3, glucose

24. Which of the following is not an oxidation-reduction equation?

SEE NEXT PAGE

(a) $2I^-(aq) + Br_2(l) \rightarrow 2Br^-(aq) + I_2(s)$

(b) $2H^+(aq) + Na_2CO_3(s) \rightarrow 2Na^+(aq) + H_2O(l) + CO_2(g)$

(c) $CuO(s) + H_2(g) \rightarrow Cu(s) + H_2O(l)$

(d) $3MnO_4{}^{2-}(aq) + 4H^+(aq) \rightarrow 2MnO_4{}^-(aq) + MnO_2(s) + 2H_2O(l)$

25.   Which of the following lists of aliphatic hydrocarbons contains an alkane, an alkene and an alkyne in that order?

(a) CH_4, C_3H_6, C_2H_2

(b) C_2H_6, C_2H_4, C_4H_8

(c) C_3H_8, C_2H_6, C_3H_4

(d) C_2H_2, C_5H_{10}, C_2H_4

26.   Which of these pressures is the lowest?

(a)   Standard pressure

(b)   1000 mm Hg

(c)   0.5 MPa

(d)   0.5 atmospheres

27.   A student makes the following statements concerning the activated complex:

        I   When particles collide they form an activated complex.

        II   Bond breaking and bond forming occurs at the activated complex.

        III Can be clearly identified during the reaction.

        IV It is the highest energy state for the reacting system.

Which of the above statements are correct?

(a)   I and II only.

(b)   I and IV only.

(c)   II and IV only.

(d)   They are all correct.

28. The following questions relate to this equation:

    $$HPO_4^{2-}(aq) + H_2O(l) \rightleftharpoons H_2PO_4^{-}(aq) + OH^{-}(aq)$$
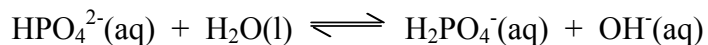
    Which of the following statements is false?

    (a) The HPO_4^{2-} behaves as a base.

    (b) The hydroxide ion is acting as a conjugate acid.

    (c) The $H_2PO_4^{-}$ is acting as an acid.

    (d) The water is acting as an acid.

29. Choose the set of stoichiometric coefficients that correctly balances the following oxidation-reduction equation:

    $$a\ MnO_4^{-} + b\ Fe^{2+} + c\ H^{+} \rightarrow d\ Mn^{2+} + e\ Fe^{3+} + f\ H_2O$$
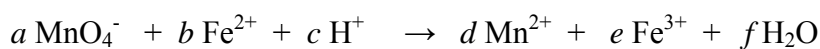
	a	b	c	d	e	f
(a)	1	1	4	1	1	4
(b)	1	5	8	1	5	4
(c)	1	3	2	1	2	4
(d)	5	1	10	5	1	20

30. In which of the following do both substances exhibit cis-trans geometric isomerism?

    (a) $CHClCHCl$, $CH_3CHCHCH_3$

    (b) CH_2ClCH_2Cl, CH_3CHCH_2

    (c) $CH_2CHCHCH_2$, CH_3CHCCl_2

    (d) C_2H_2, $CH_2ClCHCl$

END OF PART 1

PART 2: Short Answer Section (Various marks - 35% of the paper)

Answer questions in Part 2 in the spaces provided in this Question/Answer Booklet.

1.   Write equations for any reactions that occur in the following procedures.
     If no reaction occurs, write "no reaction".
     In each case describe in full what you would observe, including any colours, odours, precipitates (give colour), gases evolved (give colour or describe as colourless).
     Where appropriate, your equations should refer only to the actual species involved.

(a)   1.0 mol L^{-1} barium nitrate solution is mixed with 1.0 mol L^{-1} sodium carbonate solution.

Equation : ....

Observation : ....

     ....

                                                                                                                [3 marks]

(b)   Chunks of limestone are placed into a 2.0 mol L^{-1} hydrochloric acid solution.

Equation : ....

Observation : ....

     ....

                                                                                                                [3 marks]

(c)   Solid aluminium hydroxide is added to a sodium hydroxide solution.

Equation : ....

Observation : ....

     ....

                                                                                                                [3 marks]

2   (a)   Write the electron configuration for the following:

          (i)   a nitrogen atom ....

          (ii)   a nitride ion ....

     (b)   Write the formulae of **two** ions which could have each of the following electron configurations:

          (i)   2, 8, 8   .... and ....

          (ii)   2   .... and ....

                                                                                                                [6 marks]

SEE NEXT PAGE

3. Explain the following:

    (a) Solid sodium chloride does not conduct an electric current whereas molten and aqueous sodium chloride does.

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    (b) The existence of fractional atomic weights of some elements.

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    (c) Metals are malleable and ductile (refer to structure and bonding).

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    (d) The behaviour of real gases at high pressure deviates from that expected by the kinetic theory.

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    (e) In terms of electron configuration, why is neon a monatomic gas while fluorine is diatomic?

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[10 marks]

4. Sulfuric acid is one of the world's most important chemicals. Industrially it is manufactured in three steps in the Contact process.

The second stage in the process is the oxidation of sulfur dioxide to sulfur trioxide as indicated:

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g) + heat$$
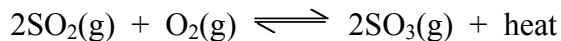
(a) On the following graph, label the axes and the appropriate regions on the graph that represent the activation energy, heat of reaction, potential energies of reactants and products and activated complex.

[4 marks]

To maximise the yield of SO_3, this procedure uses a catalyst: V_2O_5.

(b) (i) Using a different colour on the graph above, draw a line that would represent a catalysed reaction.   [1 mark]

(ii) Explain why this increases the rate of the reaction?

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[2 marks]

(c) List two other ways in which the rate of this particular reaction could be increased?

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....
....
[2 marks]

5   (a) State the oxidation number of the element underlined in each of the following:

SEE NEXT PAGE

   (i) $\underline{Mn}O_2$: oxidation number = ...

   (ii) $\underline{Mn}O_4^-$: oxidation number = ...

   (iii) $Na_2\underline{O}_2$: oxidation number = ...

[3 marks]
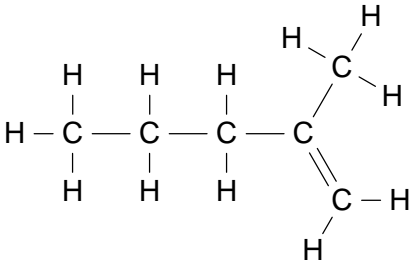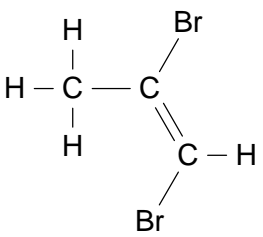
(b) Complete the table by identifying the oxidant in each reaction:

	reactions	oxidant
(i)	$Mg(s) + 2H^+(aq) \rightarrow Mg^{2+}(aq) + H_2(g)$	
(ii)	$Cu_2O(s) + H^+(aq) \rightarrow Cu(s) + Cu^{2+}(aq) + H_2O$	
(iii)	$Zn(s) + Cl_2(g) \rightarrow ZnCl_2(s)$	

[3 marks]

6.   Complete the table below by either naming or drawing the organic compound - whichever is missing. When drawing compounds, use structural formulae and show all hydrogen atoms as appropriate.

SEE NEXT PAGE

Structure	IUPAC name
(a)	methylcyclohexane
(b) structure: H–C(H)(H)–C(H)(H)–C(H)(H)–C(=CH–H)(CH₃ i.e. C–H H H on top)	(b)
(c)	2-butyne
(d) structure: H–C(H)(H)–C(Br)=C(H)(Br)	(d)

[4 marks]

7.   Complete the following table by:

(a) Drawing electron dot diagrams for the species listed.

(b) Stating the type of bonding within the species drawn.

Species	Electron dot diagram	Type of bonding
$CO_3{}^{2-}$		
O_3		
KCl		

[6 marks]

8.   Explain how you could distinguish between the following pairs of substances using **chemical** tests.

SEE NEXT PAGE

	Compounds	Description of test	Observations
(a)	$O_2(g)$		with O_2
	$CO_2(g)$		with CO_2
(b)	$NaCl(s)$		with NaCl
	$NaNO_3(s)$		with $NaNO_3$

[4 marks]

9. (a) What distinguishes temporary hardness from permanent hardness in relation to water?

....

....[1 mark]

(b) What is the main advantage of using $Na_2[Na_4(PO_3)_6]$ as a water softener rather than Na_2CO_3?

....

....[1 mark]

(c) What is deionised water?

....

....[1 mark]

(d) Write an equation that shows the development of stalagmites within a cave system.

....[1 mark]

10 (a) Write equations to describe the laboratory preparation of $HCl(g)$ and $Cl_2(g)$

    (i) Laboratory preparation of $HCl(g)$

Equation: ....
[2 marks]

(ii) Laboratory preparation of $Cl_2(g)$

Equation: ....
[2 marks]

(b) (i) What physical property can be used to distinguish between these two gases?

....
[1 mark]

(ii) How does this physical property distinguish between them?

....
[1 mark]

(c)   Explain how and why these gases are collected as they are.

....

....
[2 marks]

11.   In a Ni-Cd rechargeable cell, cadmium is oxidised to cadmium hydroxide $[Cd(OH)_2]$ in an alkaline environment.

(a) How does the oxidation number of the cadmium change in the reaction (be specific)?

....
[1 mark]

(b) Write the appropriate half-equation for this reaction.

....
[2 marks]

In the same battery, nickel gets reduced according to the equation:

$$NiO(OH)(s) \;+\; H_2O(l) \;+\; e^- \;\rightarrow\; Ni(OH)_2(s) \;+\; OH^-(aq)$$
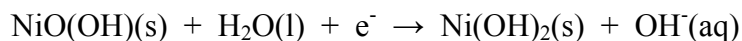
(c) How does the oxidation number of the nickel change in the reaction (be specific)?

....
[1 mark]

END OF PART 2

PART 3: Calculations (Various marks - 25% of the paper)

SEE NEXT PAGE

The calculations are to be set out in detail in this Question /Answer Booklet. Marks will be allocated for correct equations and clear setting out, even if you cannot complete the problem. When questions are divided into sections labelled (a), (b), etc, you must answer in the sections labelled (a), (b), etc. You must give your final numerical answer to three (3) significant figures, and you must provide units where applicable. Information which may be necessary for solving the problems is located on the separate Chemistry Data Sheet.

1.   A 6.30 gram sample of manganese (II) chloride is dissolved in 100 mL of distilled water. The solution was then added to 125 mL of 0.320 mol L^{-1} potassium hydroxide solution. A pale pink precipitate was produced.

   (a)   Write a balanced ionic equation for the reaction that occurred.

   .... [2 marks]

   (b)   After calculating the number of moles of manganese (II) chloride and potassium hydroxide in the reaction mixture, determine the limiting reagent.   [5 marks]

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   (c)   What mass of precipitate can be expected?   [3 marks]

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   (d)   Find the concentration in mol L^{-1} of the ions left in solution.   [5 marks]

SEE NEXT PAGE

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2.   A student chemist had a 10 L stock solution of hydrochloric acid. The pH of this solution
        was 2. Knowing that pH is related to the hydrogen ion concentration according to the formula

pH $= -\log_{10}[H^+]$, the student calculated that the concentration of the hydrochloric acid solution was 1.00×10^{-2} mol L^{-1}. The student decided that he was going to neutralise the acid with a base. He weighed out 5.00 g of potassium hydroxide, dissolved it in distilled water in a 1000 mL volumetric flask and made it up to the mark. The student then added this solution to the hydrochloric acid solution.

(a)   What was the concentration of the hydrochloric acid solution after the attempted neutralisation?   [7 marks]

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The student decided to continue with the neutralisation process. He weighed out a 4.300 g sample of $Na_2CO_3.xH_2O$. He placed it in an oven at 110^oC for 24 hours. When that time had elapsed he reweighed the sample and it weighed 1.600 g. Using distilled water and a 500 mL volumetric flask he made up a standard solution.

(b)   What volume of this standard sodium carbonate solution is needed to complete the neutralisation?   [5 marks]

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(c) Determine the value of x in the sodium carbonate formula mentioned above.   [3 marks]

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3. Aspirin is an important substance in today's pharmaceutical industry, and one that is found in practically every home. A 500 mg sample of aspirin was analysed and found to consist of 0.300 g of carbon, 0.1776 g of oxygen and the remainder was hydrogen.

   (a)   Calculate the empirical formula of aspirin based upon these results.   [5 marks]

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   (b)   Given that the relative molecular mass of aspirin is 180.2, what is its molecular formula?

[2 marks]

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(c)   This aspirin sample came from a 1.020 g tablet. Calculate the concentration of aspirin in the tablet in parts per million and as a percentage.   [4 marks]

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4.   Two containers are connected by a closed tap. Container A has a volume of 50.0 L and contains ammonia gas at a pressure of 150 kPa. Container B has a volume of 10.0 L and contains oxygen gas at a pressure of 100 kPa. The temperature of both gases is $30^{o}C$.

(a)   The tap was opened and the gases allowed to mix. Calculate the partial pressures of the two gases and the total pressure in the container after the gases have mixed (assume the temperature remains constant).   [3 marks]

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When ignited, the mixture produces nitrogen dioxide and water vapour.

(b)   Write a balanced equation for this reaction.   [1 mark]

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(c)   Calculate the limiting reagent in this setup.   [2 marks]

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The temperature of the container at the end of the reaction was $300^{\circ}C$.

(d)   What is the partial pressure of nitrogen dioxide after the reaction?   [3 marks]

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END OF PART 3

PART 4: Extended Answer   (20 marks - 10% of the paper)

Answer **ONE** of the following extended answer questions. Where applicable, use equations, diagrams and illustrative examples of the chemistry you are describing. Marks are awarded principally for the relevant chemical content of your answer, but you will lose marks if what you write is unclear or lacks coherence. Your answer should be presented in about 2 pages in the space provided in this booklet.

1. Discuss the chemical reactions and isomerism of the different classes of hydrocarbons. Give examples and chemical reactions to help explain your answer.   [20 marks]

OR

2. In 1892 the International Union of Pure and Applied Chemistry (IUPAC) drafted a set of rules for the systematic naming of organic compounds. Discuss how these rules are applied to hydrocarbons. In addition, discuss how hydrocarbons are classified and the physical properties that they have in common.   [20 marks]

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