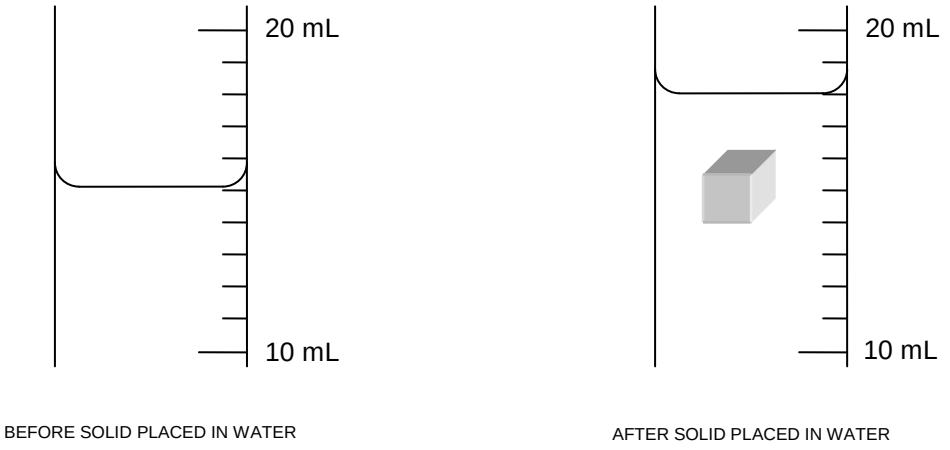
1 The diagram shows the volume of water displaced when an insoluble solid is placed in a measuring cylinder containing water. The mass of the solid is 5.70 g. ► *Bottom of cylinder is truncated.*



What is the density of the solid?

(A) 0.308 g mL^{-1}
(B) 1.90 g mL^{-1}
(C) 2.10 g mL^{-1}
(D) 28.0 g mL^{-1}

2 What does 'm' represent in the equation… $\Delta H = -m C \Delta T$?

(A) molar mass of the reactant chemical
(B) molarity of the final solution
(C) mass of the substance being heated or cooled
(D) moles of the reactant chemical

3 A solution is prepared by dissolving 1.50 g of $Ca(OH)_2$ in enough water to produce 1.00 L of solution. What is the concentration of the hydroxide ions in the solution?

(A) 3.00 g L^{-1}
(B) 2.00×10^{-2} mol L^{-1}
(C) 4.00×10^{-2} mol L^{-1}
(D) 1.50×10^{-2} g L^{-1}

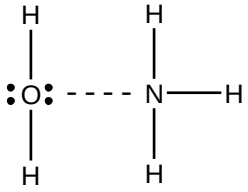
4 Which of the following is both an empirical formula and a molecular formula?

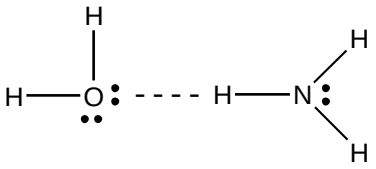
(A) CO
(B) C_3H_6
(C) $CuSO_4 \cdot 5H_2O$
(D) NaCl

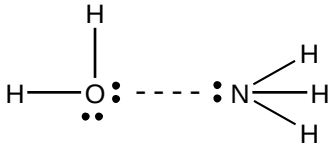
5 Which of the statements is a consequence of Avogadro's Law?

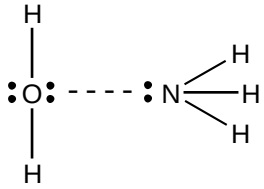
(A) The volume of one mole of CO and one mole of He are both 24.79 L at 25°C and 100 kPa.
(B) One mole of a compound contains 6.022×10^{23} molecules of that compound.
(C) Mass divided by the molar mass gives the number of moles.
(D) Gases expand when heated.

6 Which diagram shows the bonding between a water molecule and an ammonia molecule?

(A) 

(B) 

(C) 

(D) 

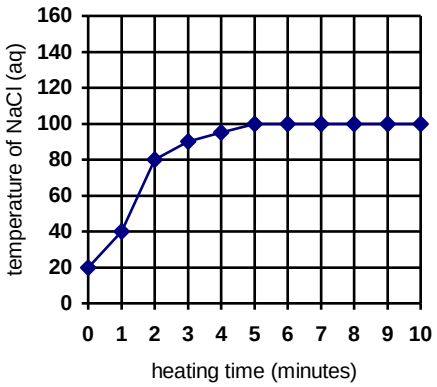
7 When one mole of sodium hydroxide is completely dissolved in water 41.6 kJ of heat energy is released. A chemistry class performed a simple calorimetry experiment to determine this value and *all* of the students got results *lower* than the accepted value.

Which statement best explains the reason for the lower values obtained?

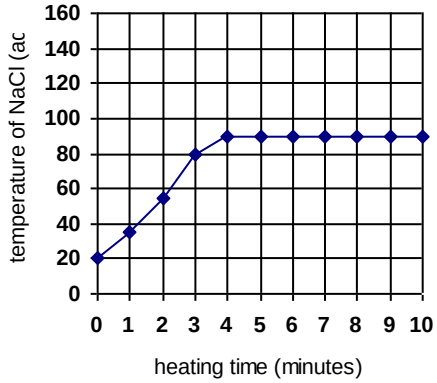
(A) The thermometers used were inaccurate.
(B) The mass of water in the cup was not accurately measured.
(C) The students didn't wait long enough for the final temperature to stabilise.
(D) Not all the heat produced by the dissolution was absorbed by the calorimeter.

8 100 mL of salt water was heated in a flask from 20°C to boiling.
Which graph best represents the heating curve?

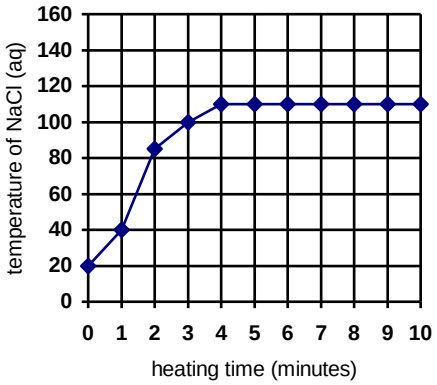
(A)



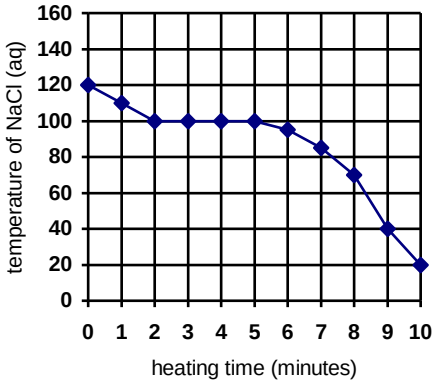
(B)



(C)

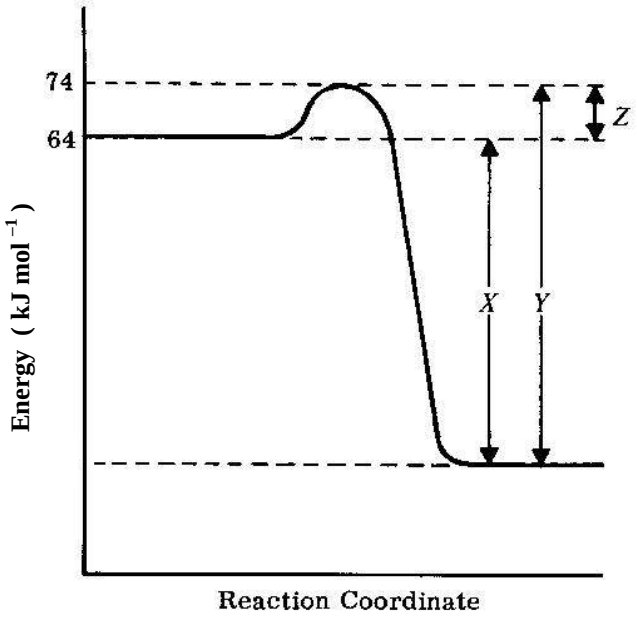


(D)



Questions 9 and 10 refer to the energy level diagram for the reaction…

$$\tfrac{1}{2}\,H_{2\,(g)} + \tfrac{1}{2}\,F_{2\,(g)} \rightleftharpoons HF_{(g)} \quad \Delta H = -64 \text{ kJ mol}^{-1}$$



9 Which statement is *incorrect?*

(A) The activation energy per mole of hydrogen fluoride formed is 10 kJ mol $^{-1}$.
(B) The activation energy of the reverse reaction is 74 kJ mol $^{-1}$.
(C) The heat of reaction per mole of hydrogen fluoride is represented by the value of X.
(D) The heat of reaction is 64 kJ mol $^{-1}$ of fluorine reacted.

10 What effect would adding a catalyst have on the reaction*?*

(A) X would stay the same and Y would become smaller.
(B) X would become smaller and Y would become larger.
(C) Both X and Y would become smaller.
(D) Z would become larger.

11 Which physical property of water can be used to explain its relatively high values for surface tension and boiling point*?*

(A) strong intermolecular forces
(B) low molecular mass
(C) low viscosity
(D) high solvency

12 Hydrogen chloride has a very high solubility in water = 70 g per 100 g H_2O at 20°C.

Which intermolecular force best explains this high aqueous solubility?

(A) dispersion force
(B) dipole – dipole force
(C) hydrogen bonding
(D) all of the above

13 To which of these reactions can Guy–Lussac's law be applied?

(A) $Fe_{(s)} + S_{(s)} \rightarrow FeS_{(s)}$
(B) $2H_{2\,(g)} + O_{2\,(g)} \rightarrow 2H_2O_{(g)}$
(C) $Ba^{2+}_{(aq)} + SO_4^{2-}{}_{(aq)} \rightarrow BaSO_{4\,(s)}$
(D) $HCl_{(aq)} + NaOH_{(aq)} \rightarrow NaCl_{(aq)} + H_2O_{(l)}$

14 One mole samples of metals are completely reacted in oxygen gas to form metal oxides. The table shows the formulae results…

METAL	METAL OXIDE FORMED
Na	Na_2O
Mg	MgO
Al	Al_2O_3
Ni	NiO_2

Which metal requires the most moles of oxygen to form an oxide?

(A) Na
(B) Mg
(C) Al
(D) Ni

15 Which of these solute types is insoluble in water?

(A) non–polar covalent
(B) covalent network
(C) large molecular
(D) all of the above

Part B – 48 marks
Attempt Questions 16 – 27
Allow about 90 minutes for this part

► ***Show all relevant working in questions involving calculations.***

Question 16 (2 marks)

Construct Lewis electron dot structures for water and hydrogen sulfide…

WATER	HYDROGEN SULFIDE

Question 17 (3 marks)

Identify whether the compound is soluble (s) or insoluble (i) in water…

Compound	NaCl	sucrose	NaOH	HCl	cellulose	SiO_2
s or i ?						

Question 18 (4 marks)

(a) Identify the physical property of water which explains its ability to moderate the temperature of aquatic environments. **(1 mark)**

_____

(b) Thermal pollution can cause serious environmental problems in waterways.

(i) Identify a source of thermal pollution. **(1 mark)**

_____

(ii) Discuss the implications for life if a body of water is affected by thermal pollution. **(2 marks)**

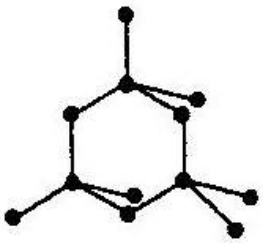
_____

_____

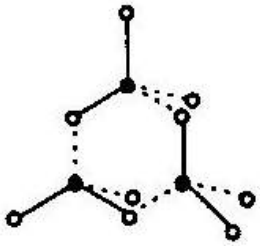
_____

Question 19 (2 marks)

The diagrams show the crystal structures of diamond and ice…



DIAMOND



ICE

Describe how these crystals are held together.

_____

_____

_____

Question 20 (6 marks)

When nickel(II) chloride ($NiCl_2$) solution is added to sodium hydroxide solution, a green precipitate forms.

(a) Write the net ionic equation for the reaction. **(1 mark)**

_____

(b) In one reaction, 60 mL of 0.20 mol L^{-1} sodium hydroxide is added to 40 mL of 0.50 mol L^{-1} solution of $NiCl_2$.

(i) Calculate the mass of precipitate formed. **(3 marks)**

_____

_____

_____

_____

_____

 Question 20 continued on page 11

Question 20 (continued)

(ii) Calculate the concentration of chloride ions in the final solution. **(2 marks)**

_____

_____

_____

Question 21 (6 marks)

Weighed samples of aluminium and magnesium were reacted with excess dilute hydrochloric acid solution, each *metal–acid* reaction producing hydrogen gas. The table shows the masses of metal reacted and the resultant volume of hydrogen gas produced at 25°C and 100 kPa.

METAL	MASS OF METAL (g)	VOLUME OF H_2 (mL)
Al	0.108	150
Mg	0.0973	100

(a) From the data in the table above, calculate these quantities… **(2 marks)**

METAL	MOLES OF METAL REACTED	MOLES OF H_2 PRODUCED
Al		
Mg		

(b) What is the mole ratio between each of the metal reacted and the hydrogen gas produced? **(1 mark)**

Al : H_2	Mg : H_2
:	:

(c) Write the balanced formulae equations for the reactions of each metal with dilute HCl. **(2 marks)**

_____

_____

 Question 21 continued on page 12

Question 21 (continued)

(d) Do the equations in (c) support the results of the experiment? Explain. **(1 mark)**

_____

_____

_____

Question 22 (2 marks)

15.9 grams of potassium dichromate ($K_2Cr_2O_7$) are dissolved in a sufficient amount of water to make up exactly 250 mL of solution.

What is the concentration of the solution? **(2 marks)**

_____

_____

_____

_____

Question 23 (1 mark)

How many hydrogen atoms are present in 25.6 g of urea, $(NH_2)_2CO$?

_____

_____

_____

_____

Question 24 (6 marks)

Nikita performs a simple calorimetry experiment to determine the molar $\Delta H_{solution}$ for KOH.
The table shows her experimental data …

Mass of water in calorimeter	150 g
Mass of KOH dissolved	5.6 g
Initial temperature of water	18°C
Final temperature of water	27°C

(a) Calculate the molar $\Delta H_{solution}$ for KOH using Nikita's data. **(3 marks)**

(b) KOH is also soluble in ethanol. Nikita plans to repeat the experiment using ethanol as the solvent instead of water and she thinks about the changes to the equation… $\Delta \boldsymbol{H} = -\boldsymbol{m}\,\boldsymbol{C}\,\Delta \boldsymbol{T}$

(i) Compare (relatively) the specific heat capacity (C) of ethanol with the value of water. **(1 mark)**

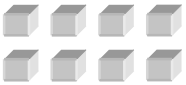
(ii) Considering your answer in (i), predict the effect on the ΔT, *i.e. will it decrease, increase or remain the same compared to the ΔT of water?* **(1 mark)**

(c) Identify a salt where $\Delta H_{solution}$ is endothermic. **(1 mark)**

Question 25 (5 marks)

(a) Kiely conducts a series of investigations on factors which effect reaction rate. In trial 1, she reacts a one centimetre cube (1 cm^3) of magnesium weighing 1.74 g with 200 mL of 3 mol L^{-1} HCl in a beaker. In trial 2, she reacts eight ½ centimetre cubes (total weight = 1.74 g) simultaneously in a beaker.

TRIAL 1



TRIAL 2

Identify which trial has the fastest rate and identify the factor which causes the effect. **(1 mark)**

(b) Kiely broadens her investigation and explores the effects of temperature and concentration on reaction rate.

(i) What effect would you predict for temperature variations and how is this effect explained on a particle level? **(2 marks)**

(ii) What effect would you predict for concentration variations and how is this effect explained on a particle level? **(2 marks)**

Question 26 (4 marks)

Propanone (C_3H_6O) is a flammable liquid used extensively as a solvent.

(a) Write a balanced chemical equation showing the complete combustion of propanone. **(1 mark)**

_____

(b) Write a balanced chemical equation showing the incomplete combustion of propanone. **(1 mark)**

_____

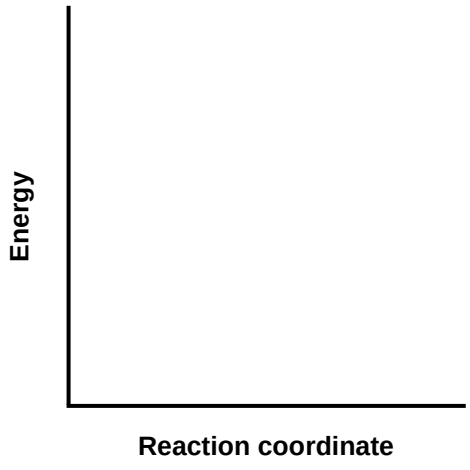
(c) Identify a pollutant produced in equation (b) and explain how its production can be avoided. **(2 marks)**

_____

_____

Question 27 (7 marks)

(a) Complete the energy level diagram by drawing in a curve for an endothermic reaction… **(1 mark)**



(b) In the diagram, draw a dashed (– – – –) line showing the effect of employing a catalyst. **(1 mark)**

 Question 27 continued on page 16

Question 27 (continued)

(c) Explain how a catalyst speeds up reaction rate. **(1 mark)**

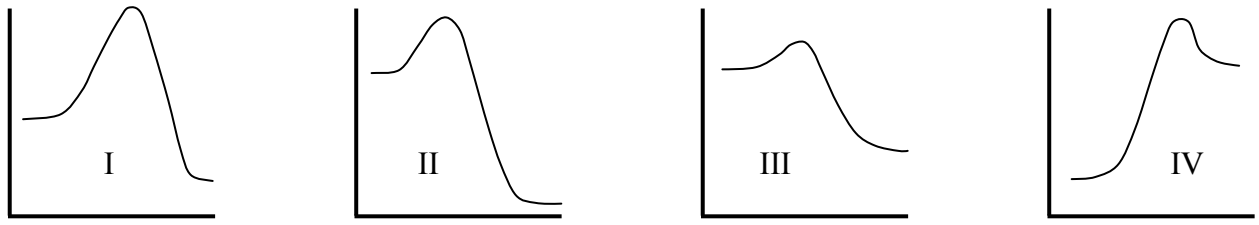
_____

_____

(d) Identify a catalyst used in industry. **(1 mark)**

_____

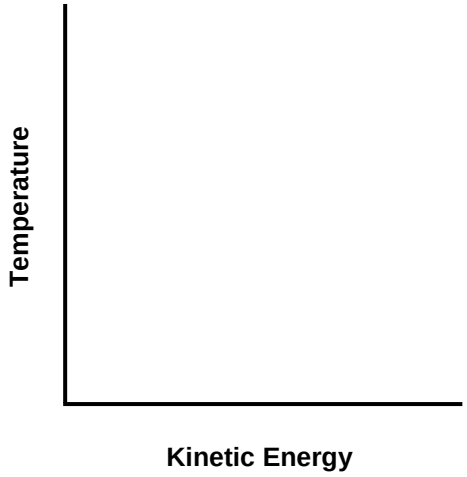
(e) Study the four energy level diagrams (I – IV) …



(i) Which diagram best represents the most easily ignitable fuel? _____ **(1 mark)**

(ii) Which diagram best represents a fuel with the highest ignition temperature? _____ **(1 mark)**

(f) Complete the graph by drawing in a line or curve showing the relative relationship between the kinetic energy of particles and the temperature as they are heated up… **(1 mark)**



END OF EXAM

DATA SHEET

Avogadro constant, N_A ..... 6.022×10^{23} mol^{-1}

Volume of 1 mole ideal gas: at 100 kPa and

at 0°C (273.15 K) ..... 22.71 L

at 25°C (298.15 K) ..... 24.79 L

Ionisation constant for water at 25°C (298.15 K), K_w ..... 1.0×10^{-14}

Specific heat capacity of water ..... 4.18×10^3 J kg^{-1} K^{-1}

Some useful formulae

$$pH = -\log_{10}[H^+] \qquad \Delta H = -mC\Delta T$$

Some standard potentials

$K^+ + e^-$	$\rightleftharpoons$	$K(s)$	–2.94 V
$Ba^{2+} + 2e^-$	$\rightleftharpoons$	$Ba(s)$	–2.91 V
$Ca^{2+} + 2e^-$	$\rightleftharpoons$	$Ca(s)$	–2.87 V
$Na^+ + e^-$	$\rightleftharpoons$	$Na(s)$	–2.71 V
$Mg^{2+} + 2e^-$	$\rightleftharpoons$	$Mg(s)$	–2.36 V
$Al^{3+} + 3e^-$	$\rightleftharpoons$	$Al(s)$	–1.68 V
$Mn^{2+} + 2e^-$	$\rightleftharpoons$	$Mn(s)$	–1.18 V
$H_2O + e^-$	$\rightleftharpoons$	$\frac{1}{2}H_2(g) + OH^-$	–0.83 V
$Zn^{2+} + 2e^-$	$\rightleftharpoons$	$Zn(s)$	–0.76 V
$Fe^{2+} + 2e^-$	$\rightleftharpoons$	$Fe(s)$	–0.44 V
$Ni^{2+} + 2e^-$	$\rightleftharpoons$	$Ni(s)$	–0.24 V
$Sn^{2+} + 2e^-$	$\rightleftharpoons$	$Sn(s)$	–0.14 V
$Pb^{2+} + 2e^-$	$\rightleftharpoons$	$Pb(s)$	–0.13 V
$H^+ + e^-$	$\rightleftharpoons$	$\frac{1}{2}H_2(g)$	0.00 V
$SO_4^{2-} + 4H^+ + 2e^-$	$\rightleftharpoons$	$SO_2(aq) + 2H_2O$	0.16 V
$Cu^{2+} + 2e^-$	$\rightleftharpoons$	$Cu(s)$	0.34 V
$\frac{1}{2}O_2(g) + H_2O + 2e^-$	$\rightleftharpoons$	$2OH^-$	0.40 V
$Cu^+ + e^-$	$\rightleftharpoons$	$Cu(s)$	0.52 V
$\frac{1}{2}I_2(s) + e^-$	$\rightleftharpoons$	I^-	0.54 V
$\frac{1}{2}I_2(aq) + e^-$	$\rightleftharpoons$	I^-	0.62 V
$Fe^{3+} + e^-$	$\rightleftharpoons$	Fe^{2+}	0.77 V
$Ag^+ + e^-$	$\rightleftharpoons$	$Ag(s)$	0.80 V
$\frac{1}{2}Br_2(l) + e^-$	$\rightleftharpoons$	Br^-	1.08 V
$\frac{1}{2}Br_2(aq) + e^-$	$\rightleftharpoons$	Br^-	1.10 V
$\frac{1}{2}O_2(g) + 2H^+ + 2e^-$	$\rightleftharpoons$	H_2O	1.23 V
$\frac{1}{2}Cl_2(g) + e^-$	$\rightleftharpoons$	Cl^-	1.36 V
$\frac{1}{2}Cr_2O_7^{2-} + 7H^+ + 3e^-$	$\rightleftharpoons$	$Cr^{3+} + \frac{7}{2}H_2O$	1.36 V
$\frac{1}{2}Cl_2(aq) + e^-$	$\rightleftharpoons$	Cl^-	1.40 V
$MnO_4^- + 8H^+ + 5e^-$	$\rightleftharpoons$	$Mn^{2+} + 4H_2O$	1.51 V
$\frac{1}{2}F_2(g) + e^-$	$\rightleftharpoons$	F^-	2.89 V

Aylward and Findlay, *SI Chemical Data* (5th Edition) is the principal source of data for this examination paper. Some data may have been modified for examination purposes.

PERIODIC TABLE OF THE ELEMENTS

KEY

Atomic Number: 79 — Symbol of element: Au

Atomic Weight: 197.0 — Name of element: Gold

1 H 1.008 Hydrogen																	2 He 4.003 Helium
3 Li 6.941 Lithium	4 Be 9.012 Beryllium											5 B 10.81 Boron	6 C 12.01 Carbon	7 N 14.01 Nitrogen	8 O 16.00 Oxygen	9 F 19.00 Fluorine	10 Ne 20.18 Neon
11 Na 22.99 Sodium	12 Mg 24.31 Magnesium											13 Al 26.98 Aluminium	14 Si 28.09 Silicon	15 P 30.97 Phosphorus	16 S 32.07 Sulfur	17 Cl 35.45 Chlorine	18 Ar 39.95 Argon
19 K 39.10 Potassium	20 Ca 40.08 Calcium	21 Sc 44.96 Scandium	22 Ti 47.87 Titanium	23 V 50.94 Vanadium	24 Cr 52.00 Chromium	25 Mn 54.94 Manganese	26 Fe 55.85 Iron	27 Co 58.93 Cobalt	28 Ni 58.69 Nickel	29 Cu 63.55 Copper	30 Zn 65.39 Zinc	31 Ga 69.72 Gallium	32 Ge 72.61 Germanium	33 As 74.92 Arsenic	34 Se 78.96 Selenium	35 Br 79.90 Bromine	36 Kr 83.80 Krypton
37 Rb 85.47 Rubidium	38 Sr 87.62 Strontium	39 Y 88.91 Yttrium	40 Zr 91.22 Zirconium	41 Nb 92.91 Niobium	42 Mo 95.94 Molybdenum	43 Tc [98.91] Technetium	44 Ru 101.1 Ruthenium	45 Rh 102.9 Rhodium	46 Pd 106.4 Palladium	47 Ag 107.9 Silver	48 Cd 112.4 Cadmium	49 In 114.8 Indium	50 Sn 118.7 Tin	51 Sb 121.8 Antimony	52 Te 127.6 Tellurium	53 I 126.9 Iodine	54 Xe 131.3 Xenon
55 Cs 132.9 Caesium	56 Ba 137.3 Barium	57–71 Lanthanides	72 Hf 178.5 Hafnium	73 Ta 180.9 Tantalum	74 W 183.8 Tungsten	75 Re 186.2 Rhenium	76 Os 190.2 Osmium	77 Ir 192.2 Iridium	78 Pt 195.1 Platinum	79 Au 197.0 Gold	80 Hg 200.6 Mercury	81 Tl 204.4 Thallium	82 Pb 207.2 Lead	83 Bi 209.0 Bismuth	84 Po [210.0] Polonium	85 At [210.0] Astatine	86 Rn [222.0] Radon
87 Fr [223.0] Francium	88 Ra [226.0] Radium	89–103 Actinides	104 Rf [261.1] Rutherfordium	105 Db [262.1] Dubnium	106 Sg [263.1] Seaborgium	107 Bh [264.1] Bohrium	108 Hs [265.1] Hassium	109 Mt [268] Meitnerium	110 Uun — Ununnilium	111 Uuu — Unununium	112 Uub — Ununbium	113	114 Uuq — Ununquadium	115	116 Uuh — Ununhexium	117	118 Uuo — Ununoctium

Lanthanides

57 La 138.9 Lanthanum	58 Ce 140.1 Cerium	59 Pr 140.9 Praseodymium	60 Nd 144.2 Neodymium	61 Pm [146.9] Promethium	62 Sm 150.4 Samarium	63 Eu 152.0 Europium	64 Gd 157.3 Gadolinium	65 Tb 158.9 Terbium	66 Dy 162.5 Dysprosium	67 Ho 164.9 Holmium	68 Er 167.3 Erbium	69 Tm 168.9 Thulium	70 Yb 173.0 Ytterbium	71 Lu 175.0 Lutetium

Actinides

89 Ac [227.0] Actinium	90 Th 232.0 Thorium	91 Pa 231.0 Protactinium	92 U 238.0 Uranium	93 Np [237.0] Neptunium	94 Pu [239.1] Plutonium	95 Am [241.1] Americium	96 Cm [244.1] Curium	97 Bk [249.1] Berkelium	98 Cf [252.1] Californium	99 Es [252.1] Einsteinium	100 Fm [257.1] Fermium	101 Md [258.1] Mendelevium	102 No [259.1] Nobelium	103 Lr [262.1] Lawrencium

Where the atomic weight is not known, the relative atomic mass of the most common radioactive isotope is shown in brackets.
The atomic weights of Np and Tc are given for the isotopes ^{237}Np and ^{99}Tc.

Multiple Choice Answers

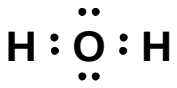
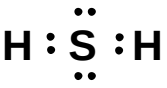
Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15
B	C	C	A	A	C	D	C	D	A	A	B	B	D	D

Part B – 48 marks
Attempt Questions 16 – 27
Allow about 90 minutes for this part

► ***Show all relevant working in questions involving calculations.***

Question 16 (2 marks)

Construct Lewis electron dot structures for water and hydrogen sulfide…

WATER	HYDROGEN SULFIDE
	

Question 17 (3 marks)

Identify whether the compound is soluble (s) or insoluble (i) in water…

Compound	NaCl	sucrose	NaOH	HCl	cellulose	SiO_2
s or i ?	**s**	**s**	**s**	**s**	**i**	**i**

Question 18 (4 marks)

(a) Identify the physical property of water which explains its ability to moderate the temperature of aquatic environments. **(1 mark)**

specific heat capacity

(b) Thermal pollution can cause serious environmental problems in waterways.

(i) Identify a source of thermal pollution. **(1 mark)**

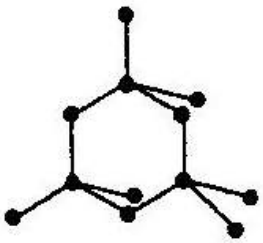
power generating stations or industrial plants

(ii) Discuss the implications for life if a body of water is affected by thermal pollution. **(2 marks)**

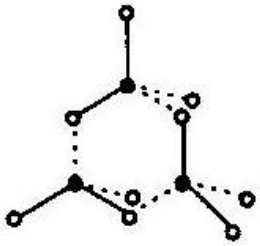
Thermal pollution causes heat stress in aquatic organisms. Heat stress has diverse consequences including increased metabolic rate, increased heart rate and decreased ability of haemoglobin (and other blood pigments, e.g. hemovanadin) to carry oxygen. Thermal pollution also decreases the amount of dissolved oxygen in water and some species of fish (e.g. trout) will not breed if the water is too warm. ► ***Any one point mentioned (1 mark) and elucidated (1 mark).***

Question 19 (2 marks)

The diagrams show the crystal structures of diamond and ice…



DIAMOND



ICE

Describe how these crystals are held together.

Diamond is held together by covalent bonds. (1 mark)

Ice is held together by hydrogen bonding. (1 mark)

Question 20 (6 marks)

When nickel(II) chloride ($NiCl_2$) solution is added to sodium hydroxide solution, a green precipitate forms.

(a) Write the net ionic equation for the reaction.

$Ni^{2+}_{(aq)} + 2OH^-_{(aq)} \rightarrow Ni(OH)_{2\,(s)}$ ► *Correct equation with phases. (1 mark)*

(b) In one reaction, 60 mL of 0.20 mol L^{-1} sodium hydroxide is added to 40 mL of 0.50 mol L^{-1} solution of $NiCl_2$.

(i) Calculate the mass of precipitate formed. **(3 marks)**

moles $NiCl_2$ = c × V = 0.50 mol L^{-1} × 0.040 L = 0.020 mol

moles NaOH = c × V = 0.20 mol L^{-1} × 0.060 L = 0.012 mol ∴ NaOH is the limiting reactant

mol $Ni(OH)_2$ = ½ mol NaOH = ½ × 0.012 mol = 0.0060 mol

mass $Ni(OH)_2$ = n × M = 0.0060 mol × 92.706 g mol^{-1} = 0.5562 = 0.56 g

► ***Correct answer with relevant working. (3 marks)***
► ***Incorrect answer with two of correct moles of $NiCl_2$ and NaOH (2 marks)***
Correct mass from incorrect mol OH^-
► ***Incorrect answer with correct mol $NiCl_2$ and NaOH (1 mark)***
or correct mass from incorrect mol OH^-
or correct answer with no working

Question 20 (continued)

(ii) Calculate the concentration of chloride ions in the final solution. **(2 marks)**

mol Cl^- = 2 × mol $NiCl_2$ = 2 × 0.020 mol = 0.040 mol (1 mark)

[Cl^-] = n ÷ V = 0.040 mol ÷ 0.10 L = 0.40 mol L^{-1} (1 mark)

Question 21 (6 marks)

Weighed samples of aluminium and magnesium were reacted with excess dilute hydrochloric acid solution, each *metal–acid* reaction producing hydrogen gas. The table shows the masses of metal reacted and the resultant volume of hydrogen gas produced at 25°C and 100 kPa.

METAL	MASS OF METAL (g)	VOLUME OF H_2 (mL)
Al	0.108	150
Mg	0.0973	100

(a) From the data in the table above, calculate these quantities… **(2 marks)**

METAL	MOLES OF METAL REACTED	MOLES OF H_2 PRODUCED
Al	**n = m ÷ M** **n = 0.108 g ÷ 26.98 g mol^{-1}** **n = 0.00400 mol**	**n = V ÷ 24.79 L mol^{-1}** **n = 0.150 L ÷ 24.79 L mol^{-1}** **n = 0.00605 mol**
Mg	**n = m ÷ M** **n = 0.0973 g ÷ 24.31 g mol^{-1}** **n = 0.00400 mol**	**n = V ÷ 24.79 L mol^{-1}** **n = 0.100 L ÷ 24.79 L mol^{-1}** **n = 0.00403 mol**

(b) What is the mole ratio between each of the metal reacted and the hydrogen gas produced? **(1 mark)**

Al : H_2	Mg : H_2
1:1.51 or 2:3	**1:1**

(c) Write the balanced formulae equations for the reactions of each metal with dilute HCl. **(2 marks)**

$$2Al_{(s)} + 6HCl_{(aq)} \rightarrow 2AlCl_{3\,(aq)} + 3H_{2\,(g)}$$

$$Mg_{(s)} + 2HCl_{(aq)} \rightarrow MgCl_{2\,(aq)} + H_{2\,(g)}$$

Question 21 continued on page 12

Question 21 (continued)

(d) Do the equations in (c) support the results of the experiment? Explain. **(1 mark)**

Yes, the results of the experiment are in concordance with the results shown by the metal to hydrogen gas ratio as expressed in the balanced equations.

Question 22 (2 marks)

15.9 grams of potassium dichromate ($K_2Cr_2O_7$) are dissolved in a sufficient amount of water to make up exactly 250 mL of solution.

What is the concentration of the solution? **(2 marks)**

moles $K_2Cr_2O_7$ = m ÷ M = 159 g ÷ 294.2 g mol $^{-1}$ = 0.540 mol (1 mark)

[$K_2Cr_2O_7$] = n ÷ V = 0.540 mol ÷ 0.250 L = 0.216 mol L $^{-1}$ (1 mark)

Question 23 (1 mark)

How many hydrogen atoms are present in 25.6 g of urea, $(NH_2)_2CO$?

moles urea = m ÷ M = 25.6 g ÷ 60.062 g mol $^{-1}$ = 0.426 mol

number of hydrogen atoms = 0.426 moles urea × 4 × 6.022 × 10^{23} atoms mol $^{-1}$

number of hydrogen atoms = 1.02 × 10^{24} atoms (1 mark)

Question 24 (6 marks)

Nikita performs a simple calorimetry experiment to determine the molar $\Delta H_{solution}$ for KOH.
The table shows her experimental data …

Mass of water in calorimeter	150 g
Mass of KOH dissolved	5.6 g
Initial temperature of water	18°C
Final temperature of water	27°C

(a) Calculate the molar $\Delta H_{solution}$ for KOH using Nikita's data. **(3 marks)**

$\Delta H = -m\,C\,\Delta T = -150\text{ g} \times 4.18\text{ J g}^{-1}\text{ C°} \times (27 - 18\text{°C}) = 5643\text{ J} = 5.643\text{ kJ}$ (1 mark)

$\Delta H\text{ g}^{-1} = \Delta H \div g_{KOH} = 5.643\text{ kJ} \div 5.6\text{ g} = 1.008\text{ kJ g}^{-1}$ (1 mark)

molar $\Delta H = \Delta H\text{ g}^{-1} \times M_{KOH} = 1.008\text{ kJ g}^{-1} \times 56.108\text{ g mol}^{-1} = 56.54 = 60\text{ kJ mol}^{-1}$ (1 mark)

► ***The final answer is expressed in one significant figure due to the ΔT subtraction calculation.***

(b) KOH is also soluble in ethanol. Nikita plans to repeat the experiment using ethanol as the solvent instead of water and she thinks about the changes to the equation… $\Delta H = -m\,C\,\Delta T$

(i) Compare (relatively) the specific heat capacity (C) of ethanol with the value of water. **(1 mark)**

$C_{ethanol} < C_{water}$

(ii) Considering your answer in (i), predict the effect on the ΔT, *i.e. will it decrease, increase or remain the same compared to the ΔT of water?* **(1 mark)**

Ethanol's lower specific heat capacity would cause the ΔT to be greater than water's.

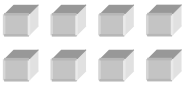
(c) Identify a salt where $\Delta H_{solution}$ is endothermic. **(1 mark)**

$AgNO_3$ $CuSO_4 \cdot 5H_2O$ KCl KI KNO_3 $MgSO_4 \cdot 7H_2O$ NaCl $NaNO_3$ $Na_2SO_4 \cdot 10H_2O$ NH_4Cl NH_4NO_3

Question 25 (5 marks)

(a) Kiely conducts a series of investigations on factors which effect reaction rate. In trial 1, she reacts a one centimetre cube (1 cm^3) of magnesium weighing 1.74 g with 200 mL of 3 mol L^{-1} HCl in a beaker. In trial 2, she reacts eight ½ centimetre cubes (total weight = 1.74 g) simultaneously in a beaker.

TRIAL 1



TRIAL 2

Identify which trial has the fastest rate and identify the factor which causes the effect. **(1 mark)**

Trial 2 has the fastest rate because the magnesium cubes have greater surface area.

(b) Kiely broadens her investigation and explores the effects of temperature and concentration on reaction rate.

(i) What effect would you predict for temperature variations and how is this effect explained on a particle level? **(2 marks)**

An increase in temperature would increase reaction rate. (1 mark)

This effect is primarily explained by the fact that more reactant molecules will have more energy to react properly, i.e. exceed the activation energy requirement. (1 mark)

► *A minor effect is the increase in collision frequency of the reactant molecules… an answer grudgingly accepted!*

(ii) What effect would you predict for concentration variations and how is this effect explained on a particle level? **(2 marks)**

An increase in reactant concentration would increase reaction rate. (1 mark)

This effect is explained by the fact that the collision frequency of the reactant molecules will increase. (1 mark)

► *An increase in the concentration of only one of the reactants will cause this effect.*

Question 26 (4 marks)

Propanone (C_3H_6O) is a flammable liquid used extensively as a solvent.

(a) Write a balanced chemical equation showing the complete combustion of propanone. **(1 mark)**

$$C_3H_6O_{(l)} + 4O_{2(g)} \rightarrow 3CO_{2(g)} + 3H_2O_{(l)}$$

(b) Write a balanced chemical equation showing the incomplete combustion of propanone. **(1 mark)**

$$C_3H_6O_{(l)} + 2\tfrac{1}{2}\,O_{2(g)} \rightarrow C_{(s)} + CO_{(g)} + CO_{2(g)} + 3H_2O_{(l)}$$

► ***Several other equations are possible.***

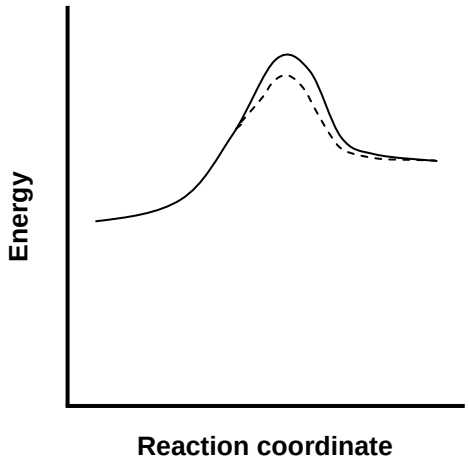
(c) Identify a pollutant produced in equation (b) and explain how its production can be avoided. **(2 marks)**

C or CO is a pollutant. (1 mark)

Pollution can be avoided by providing sufficient oxygen to the combusting fuel. (1 mark)

Question 27 (7 marks)

(a) Complete the energy level diagram by drawing in a curve for an endothermic reaction… **(1 mark)**



(b) In the diagram, draw a dashed (– – – –) line showing the effect of employing a catalyst. **(1 mark)**

Question 27 (continued)

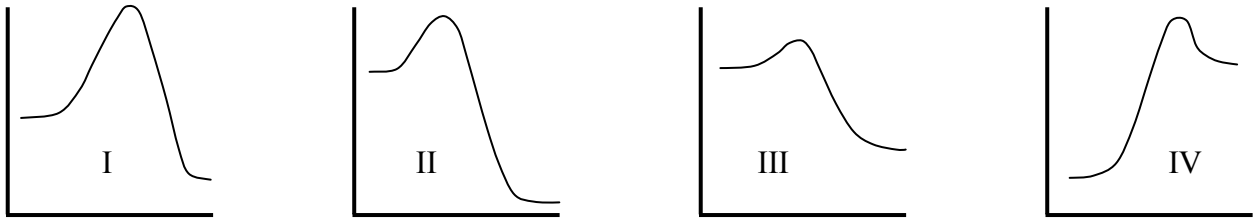
(c) Explain how a catalyst speeds up reaction rate. **(1 mark)**

Catalysts speed up reaction rates tremendously by providing an alternative reaction mechanism (pathway) with a lower activation energy.

(d) Identify a catalyst used in industry. **(1 mark)**

Nickel (margarine manufacture), platinum (diverse uses), Fe_3O_4 (ammonia manufacture), V_2O_5 (sulfuric acid manufacture). ► ***Only name or formula is required.***

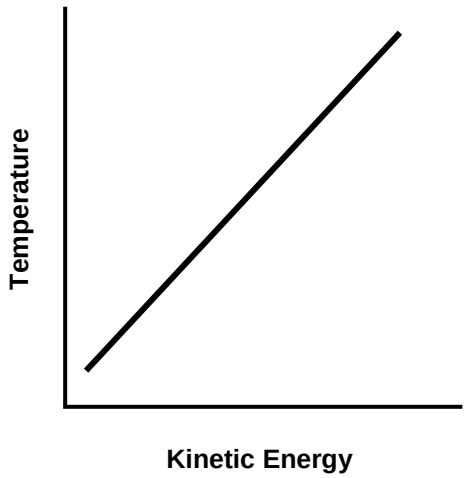
(e) Study the four energy level diagrams (I – IV) …



(i) Which diagram best represents the most easily ignitable fuel? **III** **(1 mark)**

(ii) Which diagram best represents a fuel with the highest ignition temperature? **I** **(1 mark)**

(f) Complete the graph by drawing in a line or curve showing the relative relationship between the kinetic energy of particles and the temperature as they are heated up… **(1 mark)**



► ***Temperature is directly proportional to the average kinetic energy of the particles.***