2022

Higher School Certificate

Year 11 Yearly Examination

Chemistry

General Instructions

- Reading time – 5 minutes
- Working time – 2 hours
- Board approved calculators may be used
- Write using black pen
- A data sheet, formulae sheets and periodic table are provided
- Draw diagrams using pencil
- A ruler is required

Write your NESA number in the spaces provided in the written section of the paper

Total marks – 75

Section I – Pages 3-12
20 marks
Attempt Questions 1–20
Allow 35 minutes for this section
Write your answers on the multiple choice grid on page 13 of writing booklet

Section II – Pages 13– 27
55 marks
Attempt Questions 21–29
Allow 1 hour and 25 minutes for this section

This paper MUST NOT be removed from the examination room

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1. A sample of an element was tested and shown to have the following physical and chemical properties.

Physical properties	**Chemical properties**
Solid at 25°C	*Forms dull coating when exposed to air*
Sample easily cut with knife, revealing shiny, silver appearance.	*Reacts readily with water to form a colourless gas*
Melting point of 63.5°C	*Reaction with chlorine gas is violent. Analysis of white solid produced shows it has a molecular mass of 74.55*

Which element below would have properties consistent with those listed in the table?

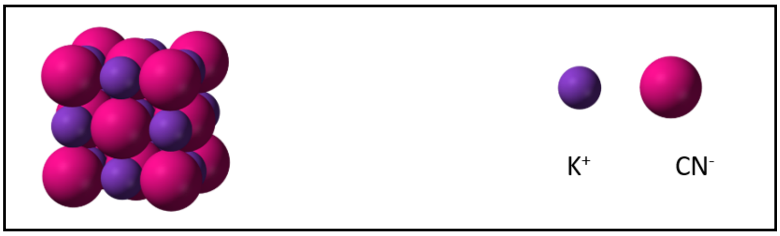
(A) sodium

(B) calcium

(C) potassium

(D) magnesium

2. Potassium cyanide (KCN) is a compound used in gold mining. It has the following crystal structure.



Which type of chemical bonding is present between K^+ and CN^- and between the C and the N in CN^-?

	Bond Between K^+ and CN^-	**Bond Between C and the N in CN^-**
(A)	ionic	single covalent
(B)	ionic	triple covalent
(C)	metallic	single covalent
(D)	metallic	triple covalent

3. Which of the following equations correctly represents the reaction of magnesium carbonate with sulfuric acid?

(A) $MgCO_{3(s)} + H_2SO_{4(aq)} \rightarrow MgSO_{4(aq)} + H_2O_{(l)} + CO_{2(g)}$

(B) $MgCO_{3(s)} + H_2SO_{4(aq)} \rightarrow MgSO_{4(aq)} + H_2O_{(l)}$

(C) $MgCO_{3(s)} + H_2SO_{4(aq)} \rightarrow MgSO_{4(aq)} + H_{2(g)}$

(D) $MgCO_{3(s)} + H_2SO_{4(aq)} \rightarrow MgSO_{4(aq)} + H_{2(g)} + CO_{2(g)}$

4. Which of the following gases will occupy 22.71 L at 100 kPa and 0°C (273.15 K)?

(A) 5.0 g of H_2

(B) 20 g of O_2

(C) 50 g of NO_2

(D) 64 g of SO_2

5. How many chloride ions are in 0.100 mol of magnesium chloride?

(A) 6.02×10^{22}

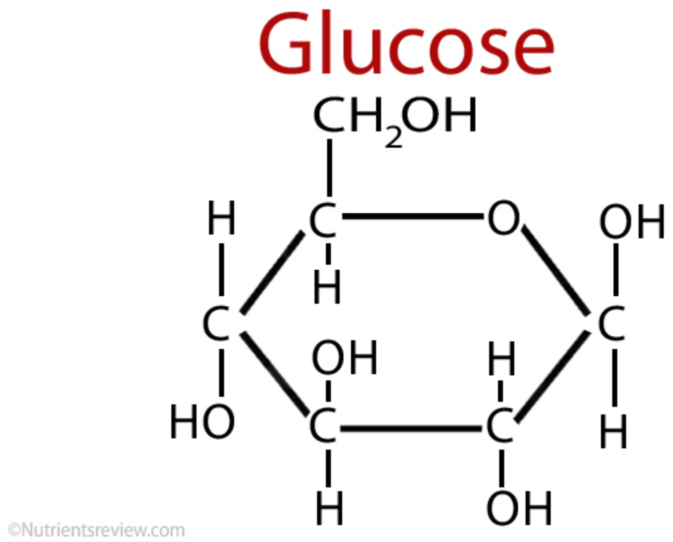
(B) 1.20×10^{23}

(C) 6.02×10^{23}

(D) 1.20×10^{24}

Questions 6 - 8 refer to the image below.

The image shows a single molecule of glucose.



6. On the basis of *the diagram alone*, which of the statements below is correct?

(A) Part of the glucose molecule consists of a ring of 6 carbon atoms.

(B) For every carbon atom in a glucose molecule there are 3 hydrogen atoms.

(C) A glucose molecule is composed of three different types of atoms.

(D) Glucose molecules are made of the same elements found in other sugars.

7. What would be the approximate mass of 0.50 moles of glucose?

(A) 30 g

(B) 60 g

(C) 90 g

(D) 120 g

8. How many oxygen atoms would be present in a 2 mol sample of glucose?

(A) 6

(B) 12

(C) 6 x (6.022×10^{23})

(D) 12 x (6.022×10^{23})

9. Which row of the table correctly identifies a typical physical property of a metal element and a typical physical property of a non-metal element?

	Physical property of metal	*Physical property of non-metal*
(A)	low boiling point	poor conductor of electricity
(B)	low density	malleable
(C)	high density	low melting point
(D)	malleable	high density

10. The solubility rules, such as those shown below, provide general qualitative data about the solubility of a range of ionic compounds, which can be useful when identifying ions in an unknown compound.

Solubility Rules for a range of ionic compounds

Anion or cation present in salt	General Solubility Rule	Main exceptions
Group I metal	All salts soluble	No exceptions
Ammonium	All salts soluble	No exceptions
Nitrate	All salts soluble	No exceptions
Chloride	Most salts soluble	Lead(II); mercury(II), silver
Sulfate	Most salts soluble	Lead(II); mercury(II), silver, barium
Carbonate	Most salts insoluble	Group I and ammonium cations
Hydroxide	Most salts insoluble	Group I and ammonium cations, barium

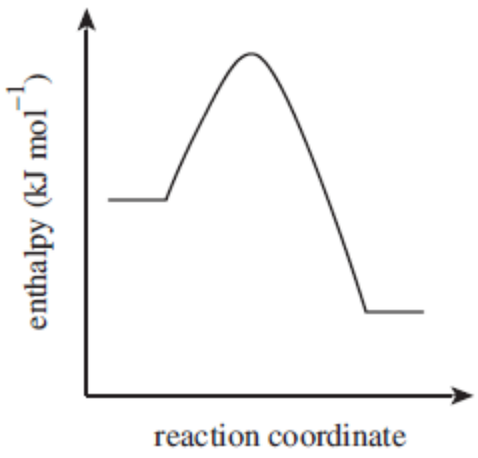
In an experiment, a student added lead (II) nitrate solution to an aqueous solution of colourless solution of an ionic compound labelled **X.** A white, opaque mixture was produced.

After filtration of the mixture, a small sample of the white solid residue, **Y**, was added to sulfuric acid, and fizzing occurred to produce a colourless gas, **Z.**

Which alternative below identifies possible compounds **X, Y** and **Z,** given the observations provided above?

	X	**Y**	**Z**
(A)	$BaCO_3$	$Pb(NO_3)_2$	CO_2
(B)	K_2CO_3	$PbCO_3$	CO_2
(C)	Na_2SO_4	$NaNO_3$	SO_2
(D)	$CuSO_4$	$Cu(NO_3)_2$	SO_2

11. An energy profile diagram for a reaction is shown.



Which of the following statements is correct?

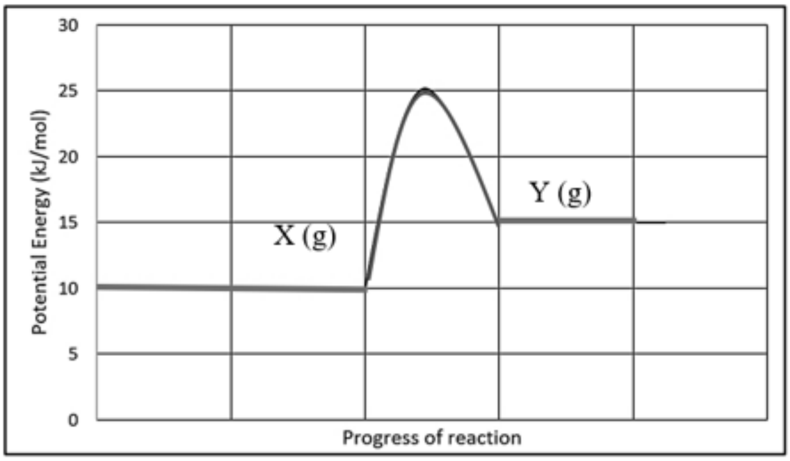
(A) The energy of the reactants is lower than the energy of the products.

(B) The energy of the reactants is the same as the energy of the products.

(C) The diagram represents the enthalpy change of an exothermic reaction.

(D) The diagram represents the enthalpy change of an endothermic reaction.

Questions 12 relates to the diagram below.



12. What is the activation energy for the conversion of one mole of X(g) into Y(g)?

(A) 5 kJ/mol

(B) 10 kJ/mol

(C) 15 kJ/mol

(D) 25 kJ/mol

13. A solution is prepared by dissolving 2.43 g of sodium hydroxide in enough water to make a 500 mL solution.

What is the concentration of hydroxide ions in the solution?

(A) 0.0122 mol L^{-1}

(B) 0.0608 mol L^{-1}

(C) 0.1215 g mol^{-1}

(D) 0.1215 mol L^{-1}

14. In which of the following samples of matter would the particles have the most kinetic energy?

(A) A liquid at 100^{o}C.

(B) A gas at 100^{o}C.

(C) A solid at 0^{o}C.

(D) A liquid at 0^{o}C.

Questions 15 and 16 relate to the following article.

"Game Changer" Catalyst for Green Hydrogen Production"

Published Sep 20, 2021 6:02 PM by **The Maritime Executive**

Liquified green hydrogen - like the fuel that will be carried by this prototype vessel - is one of the maritime industry's most promising options (Kawasaki Heavy Industries file image)

The world could commence large scale production of green hydrogen sooner than expected after researchers in Australia discovered what they described as a "gamechanger" catalyst in hydrogen production.

Researchers at Curtin University said they have identified a new, cheaper and more efficient electrocatalyst that can facilitate the making of green hydrogen from water. If confirmed, this breakthrough could open new avenues for large-scale production of the clean energy.

Green hydrogen is being touted as the fuel of the future for the maritime industry, which faces intense pressure to decarbonize in the coming decades. The industry accounts for approximately one-quarter of all emissions from the global transportation sector, emitting nearly one billion tons of CO2 annually.

According to Curtin researchers, scientists have typically been using precious metal catalysts such as platinum to accelerate the reaction to break water into hydrogen and oxygen.

However, they have found out that adding nickel and cobalt to cheaper, previously ineffective catalysts enhances their performance, which lowers the energy required to split the water and increases the yield of hydrogen.

15. Which of the following changes to the process of generating hydrogen would the newly researched nickel and cobalt-based catalysts achieve?

(A) A reduction in $CO_{2\,(g)}$ emissions from the reaction.

(B) An increase in the energy supplied to the reacting molecules.

(C) An alternate chemical reaction which is less costly to initiate.

(D) A more economic way to reduce the activation energy for the reaction.

16. Given the following bond energies:

Bond	Bond energy (kJ/mol of bonds)
H-H	432
H-O	459
O-O	142
O=O	494

Calculate the energy required (per mole of H_2) for the reaction that would produce so called 'green hydrogen' from water.

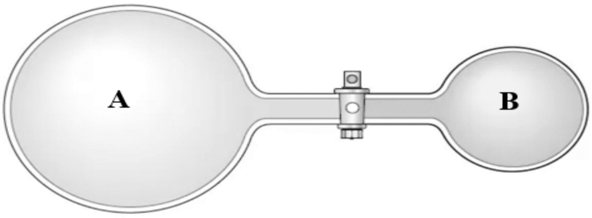
(A) +239 kJ/mol H_2

(B) +344 kJ/mol H_2

(C) +478 kJ/mol of H_2

(D) +688 kJ/mol of H_2

17. The diagram below shows 2 flasks, each holding a separate gas, joined by a valve which can be opened to allow the gases to mix.



Flask 'A' contains a 5.00 g sample of fluorine gas and has a total volume of 1.5L when the value is closed.

Flask 'B' contains the same mass of neon gas and has a total volume of 750 mL when the valve is closed. The valve between the flasks is opened allowing the gases in the flasks to mix. The temperature of the connected flasks is maintained at 15.0^{o}C and there is no reaction between the gases.

Ignoring any change to the total volume when the valve is opened, and assuming each gas behaves as an ideal gas, what pressure would be exerted by the mixture of gases in the connected flasks?

(A) 21 kPa

(B) 115 kPa

(C) 404 kPa

(D) 544 kPa

18. Titanium metal can be produced from the reaction of titanium(IV) chloride and magnesium metal, the other product being magnesium chloride.

From the correctly balanced equation for this reaction, approximately how kilograms of titanium are produced for each kilogram of magnesium used? Assume the titanium(IV) chloride is in excess.

(A) 0.5 kg

(B) 1 kg

(C) 2 kg

(D) 4 kg

19. Given the following data:

C (s) + O_2 (g)	→	CO_2(g)	ΔH= -393 kJ/mol
$2H_2$ (g) + O_2 (g)	→	$2H_2O$ (g)	ΔH= -484 kJ/mol
6C (s) + $6H_2$ (g) + $3O_2$ (g)	→	$C_6H_{12}O_6$ (s)	ΔH= -984 kJ/mol

Calculate the enthalpy change for the combustion of 90.0g of glucose ($C_6H_{12}O_6$).

(A) -1413 kJ

(B) -2139 kJ

(C) -2397 kJ

(D) -2826 kJ

20. 2.0 g of calcium carbonate reacted with 200 mL of 0.1 $molL^{-1}$ of nitric acid.

Which of the following is a correct statement about this reaction?

(A) 1.64 g of dry calcium nitrate salt is produced by the reaction.

(B) 9.9 L of carbon dioxide gas would be produced in the reaction.

(C) Approximately 0.5 g of calcium carbonate will remain after the reaction.

(D) An excess of 0.01 mol of nitric acid remains at the end of the reaction.

NESA Number: ……………………………….

Section I

20 marks
Attempt Questions 1–20
Allow about 35 minutes for this section

Select the alternative A, B, C or D that best answers the question and indicate your choice with a cross (X) in the appropriate space on the grid below.

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	A	B	C	D
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20				

Outcome	Questions	Mark
Knowledge and Understanding	MCQ(20), Q21(5), Q22(5), Q23(6)	36
Working Scientifically	Q24(10), Q25(5), Q26(6), Q27(9), Q28(5), Q29(4)	39

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Question 21 (5 marks) **Marks**

Phosphine (PH_3) is used as an insecticide in the storage of grain.

Phosphine can be produced by the reaction of water with aluminium phosphide, according to the equation:

$$AlP_{(s)} + 3H_2O_{(l)} \rightarrow PH_{3(g)} + Al(OH)_{3(aq)}$$

(a) State the type of bonding and outline the structure of phosphine. **2**

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(b) 2·900 kg of aluminium phosphide were used in a phosphine generator. **3**

Calculate the volume of phosphine gas produced in the generator (if cooled to 25°C and at a pressure of 100kPa).

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Question 22 (5 marks) **Marks**

13.00 g of hydrogen gas is reacted with 11.68 g of solid iodine to produce hydrogen iodine gas.

(a) Identify the limiting reagent and the excess reagent. **2**

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(b) Calculate the amount that the excess reagent is in excess. **1**

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(c) Calculate the mass of the hydrogen iodide gas produced. **2**

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Marks

Question 23 (6 marks)

Calcium carbonate reacts with hydrochloric acid according to the equation:

$$CaCO_{3(s)} + 2HCl_{(aq)} \rightarrow CaCl_{2(aq)} + CO_{2(g)} + H_2O_{(l)}$$

A series of experiments were conducted to investigate reaction conditions that may affect the rate of this reaction. The initial rate of the reaction under each set of conditions was estimated by measuring the rate of formation of carbon dioxide gas using a gas syringe.

The data table below shows the results of the experiments. The volume of $HCl_{(aq)}$ used in each experiment was the same.

Experiment	Mass of $CaCO_3$ powder (g)	Conc. of $HCl_{(aq)}$ ($molL^{-1}$)	Initial temperature (°C)	Final temperature (°C)	Initial rate of $CO_{2(g)}$ ($mLmin^{-1}$)
1	2.0	0.1	20	25	5
2	2.0	0.1	30	35	50
3	4.0	0.1	20	30	10
4	2.0	0.2	20	25	20

Describe three relationships between the reaction conditions tested and the initial rate of reaction and apply the collision theory to account for each relationship. **6**

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Marks

Question 24 (10 marks)

The results of an investigation in which different volumes of a 0.10 $molL^{-1}$ sodium chloride solution are added to separate 50.0 mL samples of silver nitrate solution are shown in the table below.

After each reaction, the silver chloride solid was separated via filtration, dried and weighed.

Volume sodium chloride $_{(aq)}$ added (mL)	Volume silver nitrate $_{(aq)}$ added (mL)	Mass of silver chloride produced (g)
20.0	50.0	0.29
40.0	50.0	0.58
60.0	50.0	0.87
80.0	50.0	1.16
100.0	50.0	1.44
120.0	50.0	1.44
140.0	50.0	1.43
150.0	50.0	1.45

(a) Write a balanced chemical equation for the reaction that occurred in this investigation. **1**

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Question 24 continues on page 19.

Question 24 (continued) **Marks**

(b) Construct a correctly formatted graph to show the relationship between the volume of sodium chloride solution added and the mass of silver chloride produced. Join the data points in the most appropriate manner. **4**

(c) Account for the shape of the graph. **2**

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(d) Use the graph to calculate the molarity of the silver nitrate solution used in this experiment, justifying your working **3**

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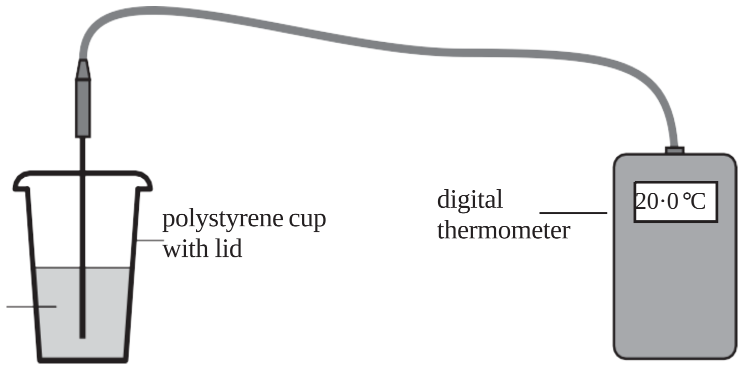
Marks

Question 25 (5 marks)

A group of students carried out an investigation into the energy changes that take place when sodium hydroxide solid dissolves in water.

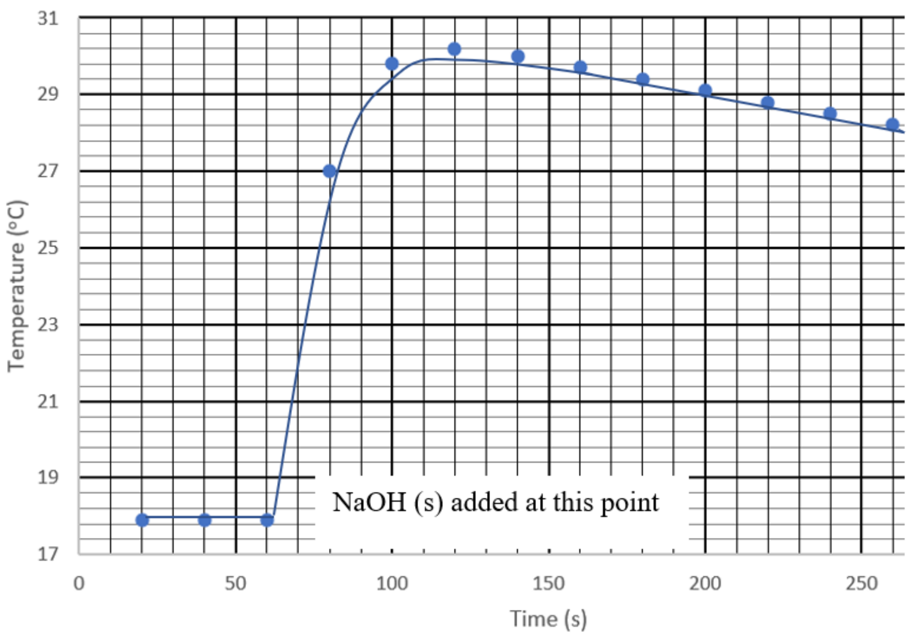
The following apparatus was used as a simple calorimeter to determine the change in temperature.



The experiment was carried out as follows.

1. 100.0 g of deionised water was added to the cup.
2. The stopwatch was started, the water stirred continuously, and the temperature recorded every 20 seconds.
3. After 60 seconds, an accurately weighed mass 5.00 g sample of the sodium hydroxide was added to the water and the temperature recorded every 20 seconds.

The results of the experiment are graphed below.



Question 25 continues on page 21.

Marks

Question 25 (continued)

(a) Use the data in the graph shown to calculate the molar heat of solution for $NaOH_{(s)}$. **3**

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(b) Justify the features of the calorimeter used in the investigation. **2**

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Marks

Question 26 (6 marks)

(a) Draw a fully labelled diagram to represent the galvanic cell you would construct if you were provided with electrodes of aluminum and tin. Include electrodes, electrolytes, ion flow, electron migration and a voltmeter in your diagram. **4**

(b) Give the net redox equation for the cell reaction in part (a) AND calculate the cell potential **2**

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Question 27 (9 marks) **Marks**

Ethylene glycol is a chemical used to depress the freezing point of water in products marketed as 'antifreeze'. It is a compound composed of C, H and O only.

A 44.80 g sample of this chemical was completely reacted with excess oxygen to form 61.6 g of carbon dioxide and 37.8 g of water.

(a) Calculate the mass of carbon and hydrogen in this sample. **2**

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(b) Determine the mass of oxygen in antifreeze and hence the empirical formula of the compound. **2**

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(c) If the molar mass of the compound is approximately 62 g mol^{-1}, determine the molecular formula of antifreeze. **1**

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Question 27 continues on page 24.

Question 27 (continued)

Marks

(d) Methanol is another compound containing carbon, hydrogen and oxygen. The molecular formula for methanol is CH_3OH.

(i) Write a balanced chemical equation for the complete combustion of liquid methanol. **1**

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(ii) Given that methanol and water mix to form a solution in any proportion, what type of intermolecular force is likely to form between molecules of the two chemicals? **1**

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(iii) Draw an electron dot diagram for a methanol molecule

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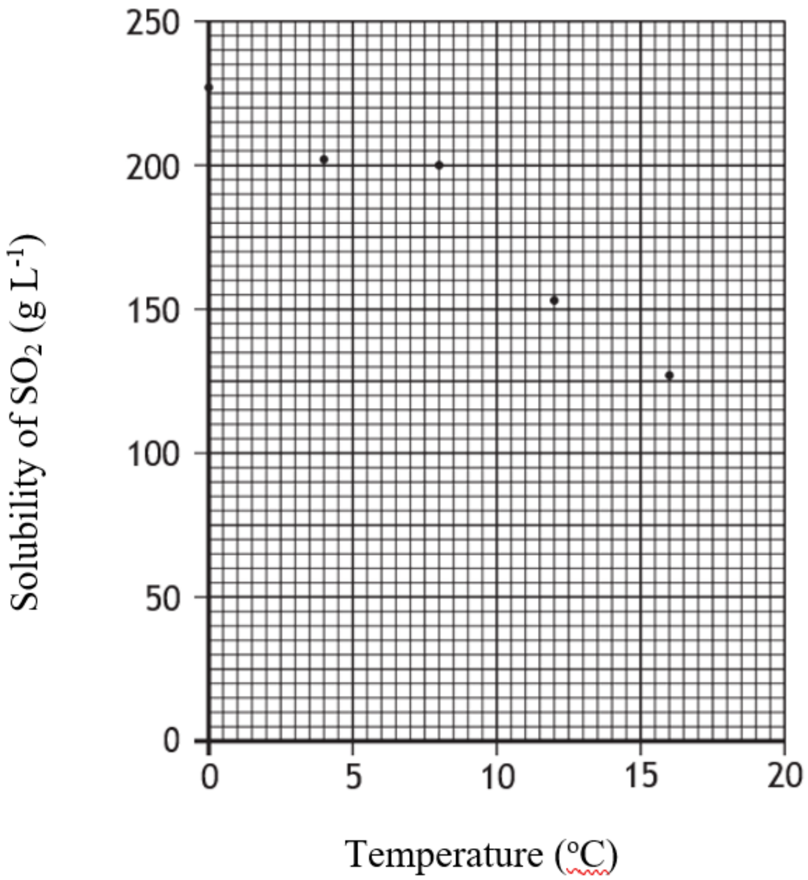
Question 28 (5 marks) **Marks**

The graph below shows results for an experiment to determine the solubility of sulfur dioxide in water at various temperatures.



(a) Calculate the number of molecules of SO_2 present in a saturated 500.0mL aqueous solution of SO_2 at a temperature of 5°C. **2**

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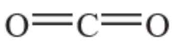
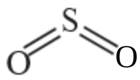
Question 28 continues on page 26.

Marks

Question 28 (continued)

(b) The table below contains some information about sulfur dioxide and carbon dioxide.

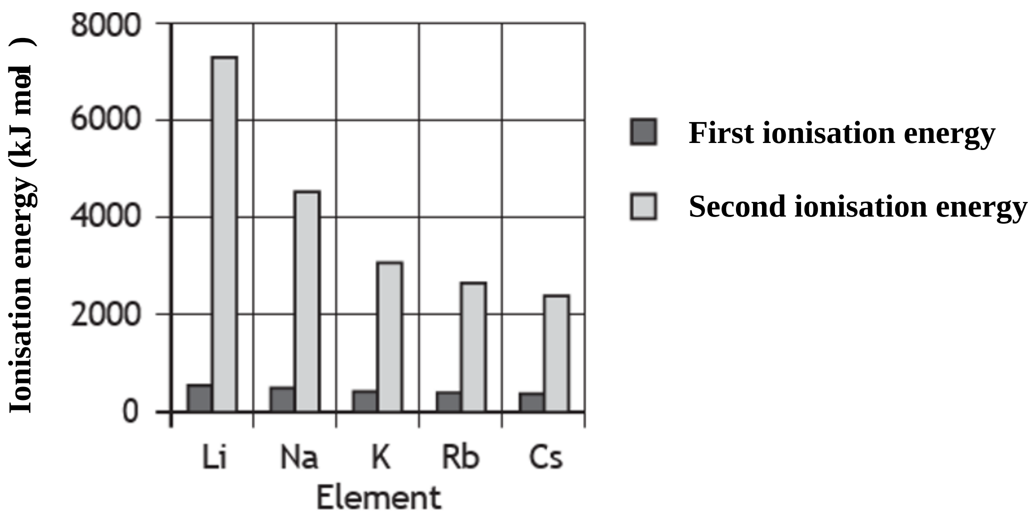
	Shape of molecule	**Electronegativity difference between elements**	**Solubility in water at 25 °C (gL^{-1})**
carbon dioxide		1·0	1·45
sulfur dioxide		1·0	94

Explain **fully** why carbon dioxide is much less soluble in water than sulfur dioxide is in water. **3**

Marks

Question 29 (4 marks)

The graph below shows data on the first and second ionisation energies of the Group 1 Metals.



Explain, using specific examples from the graph, how details of the atomic structure of these elements can be used to account for the trends shown. **4**

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End of Examination

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MCQ

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
C	B	A	D	B	B	C	D	C	B	C	C	D	B	D	A	C	B	A	A

21.a.

Marking Criteria	**Marks**
• Identifies the structure and bonding in phosphine.	**2**
• Identifies the structure or bonding in phosphine.	**1**

The bonding in phosphine is covalent and the structure is molecular. Also accepted trigonal pyramidal.

Markers Feedback
Most students were able to recognise covalent
Better student gave a diagram to show the trigonal pyramidal shape.

21.b.

Marking Criteria	**Marks**
• Calculates the volume of phosphine produced to 4 sig figs.	**3**
• Calculates the volume of phosphine produced with an error such as incorrect sig figs or no units.	**2**
• Completes one correct step in the calculation.	**1**

) 2·900 kg of aluminium phosphide were used in a phosphine generator.

Calculate the volume of phosphine gas produced in the generator (if cooled to 25°C and at a pressure of 100kPa).

m(AlP) = 2900 g
n(AlP) = m/MM = 2900 / (26.98 + 30.97) = 50.04 mol
n(PH_3) = 50.04 mol
V= n x Vm = 50.04 x 24.79 = 1240.49 = 1240 L (4 sig Fig)

Issue: 4 sig fig is what is provided in the question for the data provided – 2900kg. The 25°C and 100kPa are standard information and you don't consider the sig figs in this information as part of the calculation for sig figures.

22

(a) $H_2(g) + I_2(s) \rightarrow 2HI(g)$

$$n(H_2) = \frac{m}{MM} = \frac{13.0}{2.016} = 6.45 \text{ mol}$$

$$n(I_2) = \frac{m}{MM} = \frac{11.68}{253.8} = 0.04602 \text{ mol}$$

Iodine is the limiting reagent and hydrogen is the excess reagent.

	Marks
Correct identification of limiting reagent and excess reagent with working out	**2**
Some correct information	**1**

(b)	$n(H_2 \text{ in excess}) = 6.45 - 0.04602 = 6.40 \text{ mol}$ *Note: Consequential on answer to **Question 20(a)**.*	Mod 2 Introduction to Quantitative Chemistry CH11–9 Bands 3–4 • Calculates the correct amount of excess reagent 1
(c)	$n(HI) = 2 \times n(I_2) = 2 \times 0.04602 = 0.09204 \text{ mol}$ $m(HI) = n \times MM = 0.09204 \times 127.908 = 11.77 \text{ g}$ *Note: Consequential on answer to **Question 20(a)**.*	Mod 2 Introduction to Quantitative Chemistry CH11–9 Bands 3–4 • Calculates the amount of hydrogen iodide produced. AND • Calculates the mass of hydrogen iodide produced . . . . 2 • Provides some relevant calculations 1

Major Issue –

Very few students recognised that Iodine is a diatomic molecule I_2.

Therefore carry on errors occurred and were noted on the papers.

23.

Marking Criteria	Marks
• Describes three relationships which can be drawn from the data, identifying which trials should be compared to draw the relationship AND • Describes the main features of the collision theory and applies the correct feature/s to exaplin each relationship.	**6**
• Describes three relationships which can be drawn from the data, identifying which trials should be compared to draw the relationship AND • Outlines the main features of the collision theory and applies the correct feature/s to exaplin each relationship.	**5**
• Describes two relationships which can be drawn from the data, identifying which trials should be compared to draw the relationship AND • Outlines the main features of the collision theory and applies the correct feature/s to exaplin each relationship.	**4**
• Describes two relationships which can be drawn from the data, identifying which trials should be compared to draw the relationship AND • Accounts for one relationship in reference to features of the collsion theory	**3**
• Describes three relationships which can be drawn from the data OR • Outlines the main features of the collision theory OR • Describes at least ONE relationship which can be drawn from the data AND • Accounts for the elationship in reference to features of the collsion theory	**2**
• Provides some relevant information	**1**

The data from experiment 1 and 2 shows that increasing the temperature of the HCl increases the rate of production of CO_2. This can be explained using the collison theory, which states that in order for a reaction to occur, the molecules of the reactants must collide at the correect orientation and with sufficient energy (equal or above the reaction's activation energy). Increasing the temperature of the acid increases the rate of collisions and increases the proportion of the molecules which possess the E_A. Thus the initial reaction rate increases as reactants convert into products more quickly.

Data from experiments 4 and 6 shows that increasing the concentration of the HCl increases the rate of production of CO_2. Increasing the concentration of the HCl results in a greater frequency of collisions between the acid and calcium carbonate, thus the initial reaction rate increases as reactants convert into products more quickly.

Data from experiments 1 and 3 shows that increasing the mass of calcium carbonate powder increases the rate of production of CO_2. Increasing the mass of powder added results in a greater frequency of collisions between the acid and calcium carbonate because there is a greater surface area of powder exposed to the acid, thus the initial reaction rate increases as reactants convert into products more quickly.

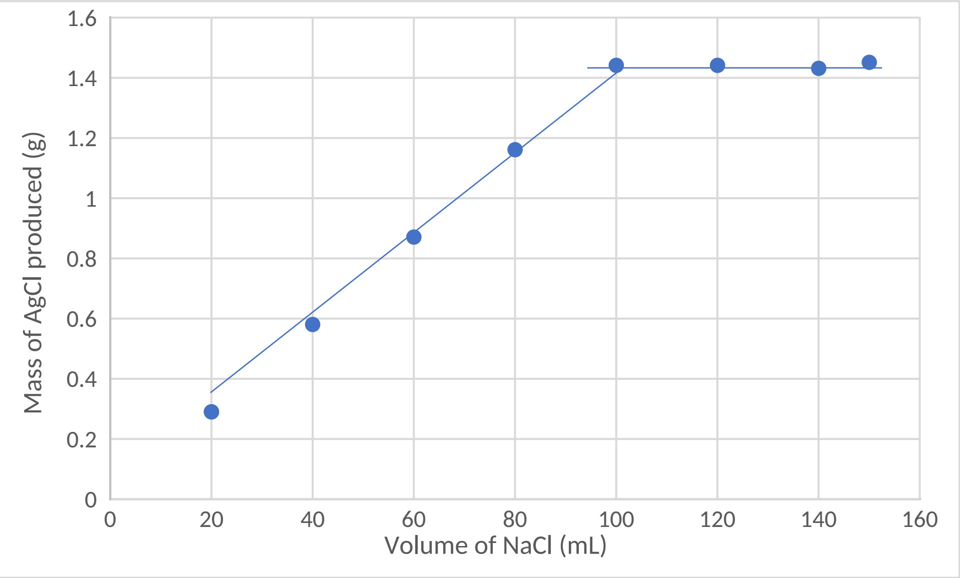
24.a.

Marking Criteria	Marks
• Writes a correctly balanced chemical equation for the reaction.	**1**

$NaCl(aq) + AgNO_3(aq) \rightarrow NaNO_3(aq) + AgCl(s)$
Feedback:
Many students were unable to provide a correctly balanced equation with AgCl

24.b.

Marking Criteria	Marks
• Draws an accurately plotted and correctly formatted graph to display the data.	**4**
• Draws an accurately plotted and well- formatted graph to display the data, with an error or omission.	**3**
• Draws a satisfactory graph with most points accurately plotted and with some features of correct fornatting.	**2**
• Graph includes some correct features.	**1**



Graphs require Titles, correctly labelled axis with units, correct scales, points plotted and lines drawn

Feedback: Make sure that titles are included and points not joined to (0,0)
24.c.

Marking Criteria	Marks
• Explains the features of the graph.	**2**
• Accounts for one feature of the graph.	**1**

As the volume of NaCl added rises initially in a regular manner, the mass of the AgCl precipitate increases in direct proportion, as the NaCl initially limits the reaction (hence increasing the moles of this reactant increases the moles of the product). However, once the volume of NaCl added exceeds roughly 100mL, the $AgNO_3$ becomes the limiting reagent, hence increasing the NaCl added has no effect on the mass of precipitate produced.

Feedback: must have information (data) linked to the graph

24.d.

Marking Criteria	Marks
• Calculates the molarity of the $AgNO_3$ with justification.	**3**
• Calculates the molarity of the $AgNO_3$.	**2**
• Provides some relevant information.	**1**

When the volume of the NaCl added is 100mL and the volume of $AgNO_3$ is 50mL, the two reagents are in correct mole ratios ie 1:1 as seen in the balanced equation.

n(NaCl) = c V = 0.1 x 0.1 = 0.01 mol
$n(AgNO_3)$ = 0.01 mol (when 50 mL is present)
$c(AgNO_3)$ = n/V = 0.01 / 0.05 = 0.2 mol L^{-1}

25.a.

Marking Criteria	Marks
• Correctly calculates the molar heat of solution of sodium chloride, including an accurate estimate of the maximum temperature change taken from the graph.	**3**
• As above with one error.	**2**
• Completes one correct step in the calculation.	**1**

q(water) = $mC\Delta T$ = 100 x 4.18 x (30.2 – 17.8) = 5183.2 J = 5.18 kJ
n(NaOH) = m/MM = 5.00 / (22.99 + 1.008 + 16) = 0.125mol
ΔH_{sol} (NaOH) = -q/n = 5.18/0.125 = 41.44 $kJmol^{-1}$

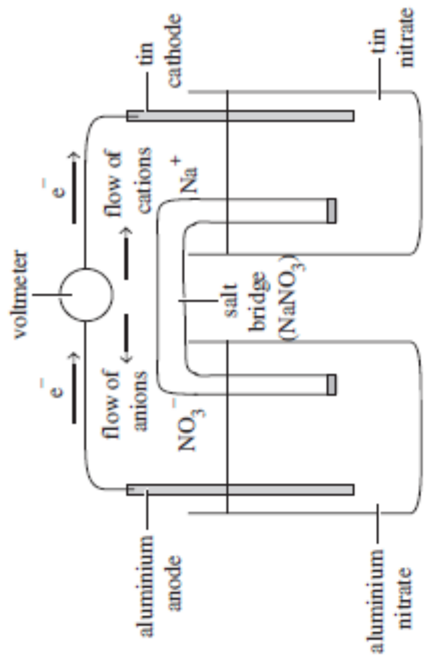
Feedback
Mass of water is 100g or 105g not 5g

25.b.

Marking Criteria	Marks
• Justifies two features of the calorimeter which improve the accuracy of the investigation.	**2**
• Suggests a valid reason for using a polystyrofoam cup or fitted lid for this investigation.	**1**

Since the aim of the investigation was to estimate the heat of solution of NaOH, design features of the calorimeter which maximise the accuracy of the estimate should be considered. A major source of error and hence inaccuracy is heat loss fron the system to the calorimeter itself and air around it. The calorimeter is made from a lightweight material which is an excllent insulator, minimising heat loss to the air and, being lightweight, not absorbing much energy to heat to the same temperature of the water. The lid further prevents heat loss to the air outside the calorimeter.

26

(a) 	Mod 3 Reactive Chemistry CH11–4, 11–6 Bands 4–6 • Draws a clear diagram. AND • Correctly labels all of: – electrolytes – aluminium anode – tin cathode – electron flow from anode to cathode – anions to anode – cations to cathode – salt bridge – voltmeter....................4
	• Draws a diagram. AND • Correctly labels at least FOUR of the above points.........3
	• Draws a diagram. AND • Correctly labels at least THREE of the above points 2
	• Gives some relevant information...1
(b) $2Al(s)+3Sn^{2+}(aq)\rightarrow 2Al^{3+}(aq)+Sn(s)$ $2Al(s)\rightarrow 2Al^{3+}(aq)+6e^-$ oxidation $3Sn^{2+}(aq)+6e^-\rightarrow 3Sn(s)$ reduction From the data sheet (standard potentials): reduction − oxidation $= -0.14\text{ V}-(-1.68\text{ V}) = 1.54\text{ V}$ **OR** $1.68+(-0.14)=1.54\text{ V}$	Mod 3 Reactive Chemistry CH11–4, 11–6 Bands 2–4 • Gives the correct redox equation. AND • Identifies the correct values from data sheet. AND • Gives correct calculation for emf of this cell...................2
	• Shows at least ONE relevant step ..1

Feedback:

27.a.

Marking Criteria	Marks
• Calculates the mass of C and H which must be present in ethylene glycol.	**2**
• Completes one correct step in the calculation.	**1**

$n(CO_2)$ = m/MM = 61.6 / 44.01 = 1.40 mol
n(C) from compound = 1.40 mol
m(C) = nxMM = 1.4 x 12.01 = 16.8g
$n(H_2O)$ = 37.8/ 18.016 = 2.098
n(H) = 2.098 x 2 = 4.19 / 1.008 = 4.16g

27.b.

Marking Criteria	Marks
• Determines through calculation the empirical formula of ethylene gylycol.	**2**
• As above with one error or omission.	**1**

m(O) in compound = 44.80 – (mass of C and H) = 23.8g

n(O) = m/MM = 23.8 / 16 = 1.49 mol

C	H	O
n=1.40	n=2.1	n=1.5
Simplest ratio: 1.4/1.4 = 1	Simplest ratio: 2.1/1.4 =1.5	Simplest ratio: 1.5/1.4=1

Hence empirical formula = CH_3O

27.c.

Marking Criteria	Marks
• Determines the molecular formula of ethylene glycol	**1**

Number of 'empirical units' in a molecule = 62 / 31 = 2

Hence molecular formula is $C_2H_6O_2$

27.di.

Marking Criteria	Marks
• Writes a correctly balanced formula for the combustion of methanol.	**1**

$2CH_4O(l) + 3O_2 (g) \rightarrow 2CO_2 (g) + 4H_2O (l)$ OR

$CH_4O(l) + 3/2\ O_2 (g) \rightarrow CO_2 (g) + 2H_2O (l)$

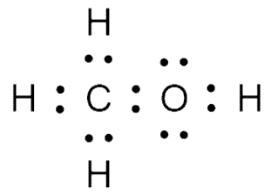
27.dii.

Marking Criteria	Marks
• Identifies the intermolecular force as a hydrogen bond	**1**

Hydrogen bonds must form between methanol and water.

27.diii.

Marking Criteria	Marks
• Draws an electron dot diagram for methanol	**2**
• Provides some relevant information	**1**



28 a.

Marking Criteria	Marks
• Calculates the number of SO_2 molecules in the saturated solution using data from the graph.	**2**
• Completes one correct step in the calculation.	**1**

At 5^{o}C, the solubility of SO_2 = 200 g /L
Hence 500mL of a saturated solution at this temperature contains 100g of SO_2
$n(SO_2)$ = m/MM = 100 / 64 = 1.56
$N(SO_2) = n \times N_a = 1.56 \times 6.022 \times 10^{23} = 9.39 \times 10^{24}$

28.b.

Marking Criteria	Marks
• Explains why CO_2 is much less soluble in water compared to SO_2 using data from the table and considering intermolecular forces present between each gas and water	**3**
• Accounts for the lower solubility of CO_2 in water compared to SO_2 considering some relevant data from the table.	**2**
• Provides some relevant information.	**1**

The solubulity of a substance in water depends on the strength of the intermolecular forces between the solute and water. Water is highly polar with strong hydrogen bonding between its molecules.

CO_2 is a non-polar molecule. Although the bonds are polar due to a difference in electronegativity of 1, the linear shape of the molecule results in non overall net dipole (the bond dipoles cancel). It thus has only dispersion forces between its molecules which cannot overcome the strong H-bonds between water. Hence its low solubility.

SO_2 also has polar bonds (same electronegativity difference) but the bent shape results in an overall net dipole, hence its molecules are somewhat polar and have dipole-dipole interactions between them. Since both water and SO_2 are polar, dipole-dipole interactions can form between their molecules accounting for its much higher solubility.

29.

Marking Criteria	Marks
• Identifies key trends shown in the graph and accounts for each by applying atomic structure.	**4**
• Identifies TWO trends shown in the graph and accounts for each by applying atomic structure.	**3**
• Identifies TWO trends shown in the graph and accounts for one by applying atomic structure.	**2**
• Provides some relevant information.	**1**

The graph shows that the first IE values of the Gp 1 metals decrease slightly as you move down the group. This is because IE values are a measure of the energy needed to remove the outermost electron from the nucleus of the gaseous atom. Since all Gr 1 metals have an s^1 valence configuartion, their 1^{st} IE values are relatively small and they decrease as the atomic radius increases, which reduces the force between the nucleus and the electron. Additional shielding of the nucleus by extra electron levels also plays a role in reducing the first IE values.

For all metals, there is a significant increase in the 2^{nd} IE values compared to the 1^{st} IE values. This is because the second electron for each metal comes from an inner shell, closer to the nucleus and less shielded from it. This makes this second electron much harder to remove. Added to this, the second electron is being removed from a positively charged ion.

The graph also shows there is a decrease in the values of the 2^{nd} IE for all metals as you move down the group. This can be explained using the principles described in the first paragraph.