Name _____ Teacher_____

Saint Ignatius' College, Riverview

2023 Preliminary Chemistry Examination

Total Marks - 70

General Instructions

- Reading time - 5 minutes
- Working time - 2 hour
- Write using blue or black pen
- Write your student number/name on the front of Multiple Choice Booklet, Multiple Choice Answer Sheet and Written Responses Booklet.
- NESA approved calculators may be used
- Chemistry Data Sheet and Periodic Table is supplied

Total marks: 70

Section I – 15 marks

- Attempt all Multiple Choice questions
- Allow about 30 mins to complete this section

Section II – 55 marks

Questions 16 - 28

- Answer all questions in the space provided.
- Allow about 1hr 30mins to complete this section

Part A: 15 Marks
Attempt Questions 1-15.
Allow about 30 minutes for this part.
Use the Multiple Choice Answer Sheet provided for Question 1-15.

Select the alternative A, B, C or D that best answers the question. Fill in the response oval completely.

Sample 2 + 4 = (A) 2 (B) 6 (C) 8 (D) 9

A ○ B ● C ○ D ○

If you think you have made a mistake, put a cross through the incorrect answer and fill in the new answer.

A ● B ⊗ C ○ D ○

If you have changed your mind and have crossed out what you consider to be the correct answer, then indicate this by writing the word *correct* and drawing an arrow as follows:

correct

A ⊗ B ● ← C ○ D ○

1. How many protons, neutrons and electrons are in an iron-56 atom?

	Protons	neutrons	electrons
A	26	26	26
B	26	30	26
C	26	26	30
D	26	26	26

2. Consider the equation:

$$2NO_{2(g)} \rightarrow 2O_{2(g)} + N_{2(g)}$$

What type of reaction does this equation represent?

A. Decomposition

B. Combustion

C. Precipitation

D. Acid/base

3. What is the oxidation number of sulfur in the ion $S_2O_6^{2-}$?

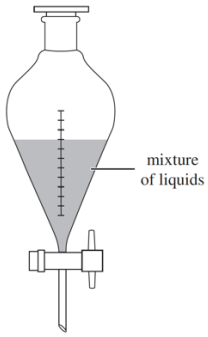
   A. -5

   B. +5

   C. +6

   D. +12

4. The diagram shows a piece of glassware that is used in the separation of liquids.



   The liquids in this glassware are separated based on which of the following properties?

   A. Gravity

   B. Boiling point

   C. Melting point

   D. Density

5. The heat of combustion of propane (C_3H_8) is -2220 kJ mol^{-1}. What is the value of the Heat of Combustion in kJ g^{-1}?

   A. 50.38

   B. 97.82

   C. 131.34

   D. 195.65

6. What volume of water, in mL, needs to be added to a 4 mL sample of 15 mol L^{-1} nitric acid for the concentration to be diluted to 2 mol L^{-1}?

A. 7.5 mL

B. 15 mL

C. 26 mL

D. 30 mL

7. Solubility rules are listed below.

Anion	***Formula***	***Cation***	
		Soluble	***Insoluble***
nitrates	NO_3^-	all	
acetates	CH_3COO^-	all	
chlorides	Cl^-	most	Ag^+, Pb^{2+}
sulfates	SO_4^{2-}	most	Ba^{2+}, Ca^{2+}, Pb^{2+}, Ag^+
sulfides	S^{2-}	Group 1, NH_4^+, Group 2	most
hydroxides	OH^-	Group 1, NH_4^+, Ba^{2+}	most
carbonates	CO_3^{2-}	Group 1, NH_4^+	most

Samples of four solutions W, X, Y and Z were added to solutions of sodium chloride, sodium sulfate and sodium hydroxide. The results are shown in the table below.

	NaCl	***Na_2SO_4***	***NaOH***
W	no precipitate	no precipitate	no precipitate
X	precipitate	no precipitate	precipitate
Y	no precipitate	precipitate	no precipitate
Z	precipitate	precipitate	precipitate

Which solution could have been lead(II)nitrate?

A. W

B. X

C. Y

D. Z

8. The Activity series of metals allow us to predict which metals will react in certain solutions. Consider the metal Fe.

   Which solution or solutions will react with iron filings?

   - Solution I: KNO_3
   - Solution II: $AgNO_3$
   - Solution III: $Zn(NO_3)_2$

   A. Solution 1 only

   B. Solution II only

   C. Solutions I and II only

   D. Solutions I, II and III

9. What mass of aluminium chloride ($AlCl_3$) is required to prepare a 500mL solution with concentration of 0.050 mol L^{-1}?

   A. 1.6 g

   B. 2.4 g

   C. 3.3 g

   D. 4.9 g

10. Which of the following statements about catalysts is NOT true?

A. provides an alternate reaction pathway

B. alters the overall enthalpy change ΔH of a reaction

C. reduces the activation energy E_a of a reaction

D. is not consumed during a reaction

11. When calcium carbonate ($CaCO_3$) is heated, it decomposes into calcium oxide and carbon dioxide according to the following reaction:

$$CaCO_3(s) \rightarrow CaO(s) + CO_2(g) \quad \Delta H = +178.3 \text{ kJ}$$

How much energy is required to decompose 21.34 g of $CaCO_3$?

A. 178.3 J

B. 17.83 kJ

C. 38.02 kJ

D. 89.00 kJ

12. Strips of magnesium metal are placed in a beaker with dilute nitric acid. Which of the following will increase the rate of the reaction?

A. Increasing the pressure

B. Decreasing the volume of the nitric acid

C. Increasing the size of the magnesium strips

D. Increasing the concentration of the nitric acid

13. Given the following data:

$C_{(s)} + O_{2(g)} \rightarrow CO_{2(g)}.$ $\Delta = -393\ kJ\ mol^{-1}$

$2H_{2(g)} + O_{2(g)} \rightarrow 2H_2O_{(g)}$ $\Delta = -484\ kJ\ mol^{-1}$

$6C_{(s)} + 6H_{2(g)} + 3O_{2(g)} \rightarrow C_6H_{12}O_{6(s)}$ $\Delta = -984\ kJ\ mol^{-1}$

Calculate the enthalpy change for the combustion of 1 mole of glucose in the equation:

$C_6H_{12}O_{6(s)} + 6O_{2(g)} \rightarrow 6CO_{2(g)} + 6H_2O_{(g)}$

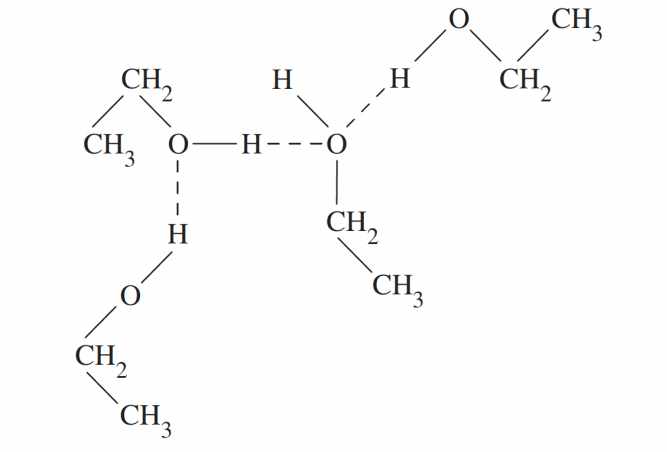
A. -1413kJ

B. -2139kJ

C. -2397kJ

D. -2826kJ

14. The dashed lines in the diagram illustrate the bonds between some molecules.



What type of bonding do the dashed lines represent?

A. Hydrogen bonding

B. Dispersion forces

C. Intramolecular forces

D. Ion-dipole forces

15. In which of the following reactions does entropy decrease?

A. $NH_4Cl(s) \rightarrow NH_3(g) + HCl(g)$

B. $NaCl(s) \rightarrow Na^+(aq) + Cl^-(aq)$

C. $N_2(g) + 2H_2(g) \rightarrow N_2H_4(l)$

D. $C_2H_5OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(g)$

End of Multiple Choice

Name _____ Teacher_____

2023 Year 11 Final Examination
Preliminary Examination

Part B – 55 marks

Attempt Questions 16-28

Allow about 1 hour and 30 minutes for this part.

Question 16 (6 marks)

Chemical Bonds are forces that hold atoms together. Complete the table.

Use IUPAC naming conventions.

Substance name	**Substance formula**	**Bonding present within substance**
	N_2O_5	
nitrogen gas		
	$(NH_4)_2SO_4$	
aluminium carbonate		
	SO_3	
silicon dioxide		

Question 17 (3 marks)

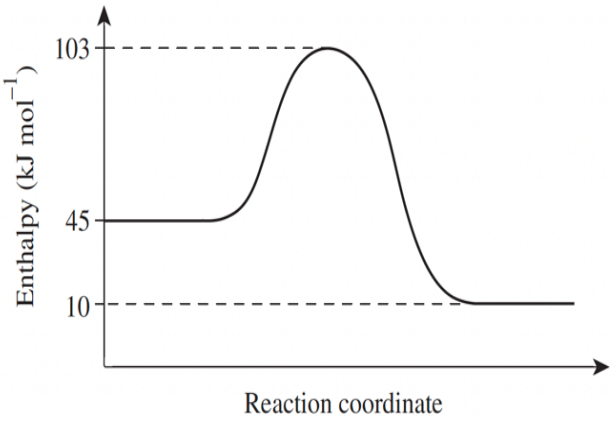
Hydrogen gas and chlorine gas react to form hydrogen chloride gas $HCl_{(g)}$ according to the following equation:

$$H_{2(g)} + Cl_{2(g)} \rightarrow 2HCl_{(g)}$$

Calculate the mass of Cl_2 that would be required to produce 267g of HCl.

Question 18 (4 marks)

The energy profile diagram of the reaction between an aqueous solution of sodium hydroxide NaOH(aq) and sulfuric acid $H_2SO_{4(aq)}$ is shown.



(a) What is the activation energy in kJ mol^{-1} of this reaction? (1 mark)

_____

(b) From the energy profile diagram, calculate the enthalpy change ΔH for this reaction and explain whether the reaction is exothermic or endothermic. (2 marks)

_____

_____

_____

(c) In this reaction, the products are sodium sulfate and water. Write a balanced chemical formula equation for this reaction including the enthalpy value in kJ mol^{-1}. (1 mark)

_____

Question 19 (5 marks)

Complete the table by describing the trends in the Periodic Table relating to the reactivity of metals, reactivity of non- metals, atomic radii and first ionisation energy.

Periodic Table property	**Describe the trends**
reactivity of metals	
reactivity of non metals	
electronegativity	
atomic radii	
first ionisation energy	

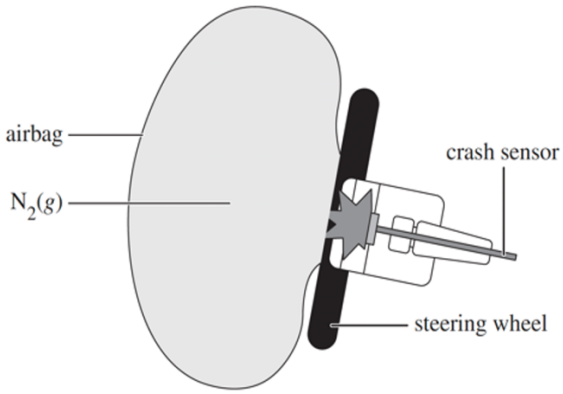
Name _____ Teacher_____

Question 20 (3 marks)

Modern cars are equipped with multiple airbags to protect occupants from sustaining injuries during a collision. On collision, the airbags are filled with nitrogen gas, which is produced by the reaction between sodium azide (NaN_3) and iron(III)oxide (Fe_2O_3).
The reaction occurs according to the following equation.

$$6NaN_{3(s)} + Fe_2O_{3(s)} \rightarrow 3Na_2O_{(s)} + 2Fe_{(s)} + 9N_{2(g)}$$

The diagram illustrates the airbag:



Calculate the mass of NaN_3, in grams, that is required to produce enough N_2 to fill an airbag that has a volume of 74.37 L. Assume that the conditions are at 25°C and 100kPa.

_____

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Question 21 (8 marks)

A student conducted an experiment using a galvanic cell.

One half cell comprised of an aluminium strip in aluminium nitrate solution $Al(NO_3)_{3(aq)}$.

The second half cell comprised of an iron strip in an iron(II)nitrate solution $Fe(NO_3)_{2(aq)}$.

(a) Write the oxidation half equation. (1 Mark)

_____

(b) Write the reduction half equation. (1 Mark)

_____

(c) Draw a fully labelled diagram of the galvanic cell used by the student. (5 Marks)

Include anode, cathode, direction of flow of electrons, salt bridge, direction of flow of ions. Label the electrolytes (solutions) in each cell.

(d) Calculate the cell potential of the galvanic cell. (1 Mark)

_____

Question 22 (6 marks)
The reaction between urea $CO(NH_2)_2$ and water occurs according to the following equation:

$$CO(NH_2)_{2(aq)} + H_2O_{(l)} \rightarrow CO_{2(g)} + 2NH_{3(g)}$$

Data about the reactants and products is shown in the table.

Substance	*Standard enthalpy of formation,* ΔH_f° *(kJ mol*$^{-1}$*)*	*Standard entropy at 25°C and 100 kPa,* ΔS° *(J mol*$^{-1}$*K*$^{-1}$*)*
carbon dioxide ($CO_2(g)$)	–393.5	213.6
urea ($CO(NH_2)_2(aq)$)	–319.2	173.8
water ($H_2O(l)$)	–285.9	69.96
ammonia ($NH_3(g)$)	–46.19	192.5

(i) Calculate Enthalpy Change ΔH for this reaction. (1 mark)

(ii) Calculate the Entropy Change ΔS for this reaction. (1 mark)

(iii) Using your calculations from (i) and (ii) and the table of data, calculate the Gibbs Free Energy ΔG of the reaction and state whether the reaction is spontaneous. (2 marks)

(iv) In an exothermic reaction with a negative entropy, explain the effect on the spontaneity of this reaction if the temperature is increased? (2 marks)

Name _____ Teacher_____

Question 23 (4 marks)

Cryolite is an ore of aluminium and its formula is Na_3AlF_6.

(a) Calculate the molar mass of Na_3AlF_6. (1 mark)

_____

_____

(b) Calculate the percentage composition of each element by mass in Na_3AlF_6. (3 marks)

_____

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Question 24 (3 marks)

A student mixed 2mL each of aqueous solutions of silver nitrate and calcium chloride.

Anion	***Formula***	***Cation***	
		Soluble	***Insoluble***
nitrates	NO_3^-	all	
acetates	CH_3COO^-	all	
chlorides	Cl^-	most	Ag^+, Pb^{2+}
sulfates	SO_4^{2-}	most	Ba^{2+}, Ca^{2+}, Pb^{2+}, Ag^+
sulfides	S^{2-}	Group 1, NH_4^+, Group 2	most
hydroxides	OH^-	Group 1, NH_4^+, Ba^{2+}	most
carbonates	CO_3^{2-}	Group 1, NH_4^+	most

Use the solubility table above to complete the following equations using subscripts.

(i) Complete the word equation: (1 mark)

Silver nitrate + calcium chloride → _____ + _____

(ii) Write the neutral species formula equation: (1 mark)

_____ + _____ → _____ + _____

(iii) Write the net ionic formula equation that occurs: (1 mark)

_____ + _____ → _____ + _____

Question 25 (3 marks)

The heat of combustion of different alcohols are shown in the table.

Alcohol	Heat of Combustion ΔHc = -ve (kJ mol^{-1})	Approx. Molar mass (g mol^{-1})
methanol CH_3OH	726	32
ethanol C_2H_5OH	1367	46
propanol C_3H_7OH	2021	60
pentanol $C_5H_{11}OH$	3331	88

(a) Using data from the table, plot a graph showing the relationship between the molar mass and ΔHc of the alcohol on the graph paper below using the ΔH values. Draw a line of best fit.

(2 marks)

(b) Using the graph, mark on the graph the Heat of Combustion for butanol (C_4H_9OH) in kJ mol^{-1}. (1 mark)

Question 26 (3 marks)

Analysis has shown that caffeine contains:

49.5% carbon, 5.2% hydrogen, 28.7% nitrogen and 16.6% oxygen by mass.

(a) Calculate the empirical formula of caffeine (2 marks)

(b) If the molar mass is 194.19g mol^{-1} calculate the molecular formula. (1 mark)

Question 27 (4 marks)

The boiling points and appropriate molecular masses of three fluorine containing compounds are shown in the table below.

Formula	**HF**	**BF_3**	**CHF_3**
Approximate molar mass	19	68	70
Boiling point (°C)	19.5	-100	-82.1

(a) Draw an electron dot formula diagram for CHF_3 (1 mark)

(b) Account for the differences in the boiling points of these three compounds. (3 marks)

Question 28 (3 marks)

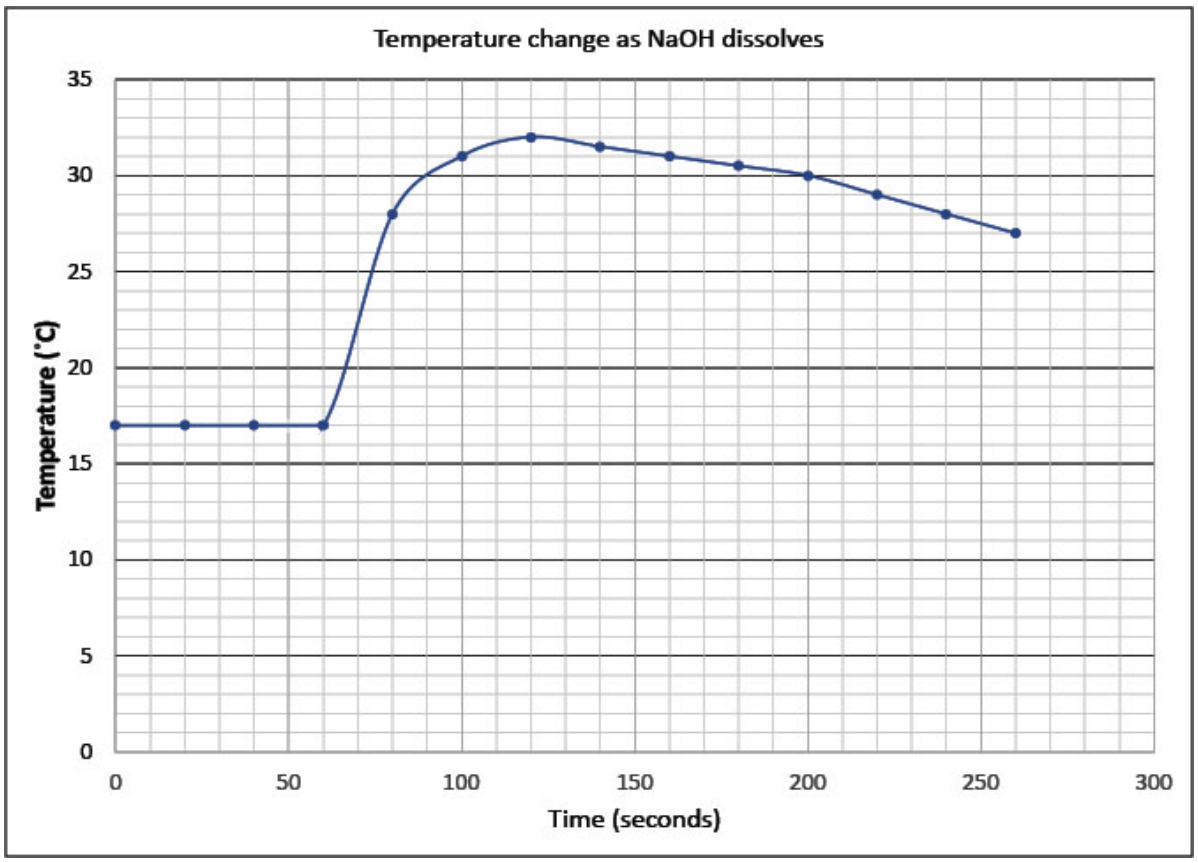
Aim: To measure the energy change when sodium hydroxide $NaOH_{(s)}$ is dissolved in water.

Equipment: A polystyrene cup was used as a calorimeter. A digital thermometer was used to measure temperature.

Method.

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

Results:



Question 28 continues on the next page

Use the data from the Method and the Graph of results to calculate the Molar Heat of Dissolution of sodium hydroxide $NaOH_{(s)}$.

End of examination

Section II extra writing space.

If you use this space indicate clearly which question you are answering.

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Saint Ignatius' College, Riverview

2023 Preliminary Chemistry Examination

Total Marks - 70

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Total marks: 70

Section I – 15 marks

- Attempt all Multiple Choice questions
- Allow about 30 mins to complete this section

Section II – 55 marks

Questions 16 - 28

- Answer all questions in the space provided.
- Allow about 1hr 30mins to complete this section

Question	Module Focus Question	Marks		Question	Module Focus Question	Marks
1	M1F2	1		15	M4F3	1
2	M3F1	1		16	M1F4	6
3	M3F2	1		17	M2F1	3
4	M1F1	1		18	M4F1	4
5	M4F1	1		19	M1F3	5
6	M2F3	1		20	M2F4	3
7	M3F1	1		21	M3F2	8
8	M3F2	1		22	M4F3	6
9	M2F3	1		23	M2F2	4
10	M4F1	1		24	M3F1	3
11	M4F1	1		25	M4F1	3
12	M3F3	1		26	M2F2	3
13	M4F1	1		27	M1F4	4
14	M1F4	1		18	M4F1	3

	MOD 1	MOD 2	MOD 3	MOD 4
MARKS	18	15	16	21

Part A: 15 Marks
Attempt Questions 1-15.
Allow about 30 minutes for this part.
Use the Multiple Choice Answer Sheet provided for Question 1-15.

Select the alternative A, B, C or D that best answers the question. Fill in the response oval completely.

Sample 2 + 4 = (A) 2 (B) 6 (C) 8 (D) 9

A ○ B ● C ○ D ○

If you think you have made a mistake, put a cross through the incorrect answer and fill in the new answer.

A ● B ⊗ C ○ D ○

If you have changed your mind and have crossed out what you consider to be the correct answer, then indicate this by writing the word *correct* and drawing an arrow as follows:

correct

A ⊗ B ⊗ ← C ○ D ○

1. How many protons, neutrons and electrons are in an iron-56 atom?

	Protons	neutrons	electrons
A	26	26	26
B	26	30	26
C	26	26	30
D	26	26	26

Answer B.
An iron-56 atom contains 26 protons and 30 neutrons (26 + 30 = 56). As the atom is neutral, it contains 26 electrons.

2. Consider the equation:

   $2NO_{2(g)} \text{ ---> } 2O_{2(g)} + N_{2(g)}$

   What type of reaction does this equation represent?

   A. Decomposition

   B. Combustion

   C. Precipitation

   D. Acid/base

Answer A:

A is correct. The equation represents the decomposition of nitrogen dioxide (NO_2) into oxygen (O_2) and nitrogen (N_2).
B is incorrect. A combustion reaction occurs between a fuel and oxygen gas to produce heat, carbon dioxide (CO_2) and water (H_2O).
C is incorrect. A precipitation reaction occurs between ions in aqueous solution to produce a precipitate.
D is incorrect. An acid/base reaction occurs between an acid and a base and involves the transfer of hydrogen ions, H^+.

3. What is the oxidation number of sulfur in the ion $S_2O_6^{2-}$?

   A. -5

   B. +5

   C. +6

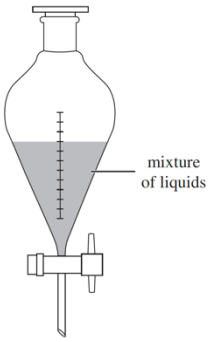
   D. +12

Question 3 **B**

The overall charge of the ion is –2. The oxidation number of oxygen is –2. If the oxidation number of sulfur is x:

$$2x + (6 \times -2) = -2$$
$$2x = 10$$
$$x = +5$$

4. The diagram shows a piece of glassware that is used in the separation of liquids.



The liquids in this glassware are separated based on which of the following properties?

A. Gravity

B. Boiling point

C. Melting point

D. Density

D is correct. The diagram shows a separating funnel, which is used to separate liquids that are immiscible with each other and also have different densities.
A and **C** are incorrect. Gravity and melting points are used for the separation of solids.
B is incorrect. Liquids cannot be separated with a separating funnel based on different boiling points.

5. The heat of combustion of propane (C_3H_8) is -2220 kJ mol^{-1}.
What is the value of the Heat of Combustion in kJ g^{-1}?

A. 50.38

B. 97.82

C. 131.34

D. 195.65

Question 5 **A**

To convert the heat of combustion from kJ mol^{-1} to kJ g^{-1}, the value of the heat of combusion should be divided by the molar mass.

Molar mass of propane (C_3H_8):

$$MM = (12.01 \times 3) + (1.008 \times 8)$$
$$= 44.094 \text{ g mol}^{-1}$$

$$\frac{2220 \text{ kJ mol}^{-1}}{44.094 \text{ g mol}^{-1}} = 50.35 \text{ kJ g}^{-1}$$

6. What volume of water, in mL, needs to be added to a 4 mL sample of 15 mol L^{-1} nitric acid for the concentration to be diluted to 2 mol L–1?

A. 7.5 mL

B. 15 mL

C. 26 mL

E. 30 mL

C. The total volume of the diluted solution can be calculated from $\frac{c_1V_1}{c_2} = \frac{15 \times 0.004}{2}$ = 0.030 L = 30 mL.

The volume of water that needs to be added is 30 – 4 = 26 mL.

7. Solubility rules are listed below.

Anion	***Formula***	***Cation***	
		Soluble	***Insoluble***
nitrates	NO_3^-	all	
acetates	CH_3COO^-	all	
chlorides	Cl^-	most	Ag^+, Pb^{2+}
sulfates	SO_4^{2-}	most	Ba^{2+}, Ca^{2+}, Pb^{2+}, Ag^+
sulfides	S^{2-}	Group 1, NH_4^+, Group 2	most
hydroxides	OH^-	Group 1, NH_4^+, Ba^{2+}	most
carbonates	CO_3^{2-}	Group 1, NH_4^+	most

Samples of four solutions W, X, Y and Z were added to solutions of sodium chloride, sodium sulfate and sodium hydroxide. The results are shown in the table below.

	NaCl	***Na_2SO_4***	***NaOH***
W	no precipitate	no precipitate	no precipitate
X	precipitate	no precipitate	precipitate
Y	no precipitate	precipitate	no precipitate
Z	precipitate	precipitate	precipitate

Which solution could have been lead(II)nitrate

A. W

B. X

C. Y

D. Z

8. The Activity series of metals allows us to predict which metals will react in certain solutions. Consider the metal Fe.

   Which solution or solutions will react with iron filings?

   - Solution I: KNO_3
   - Solution II: $AgNO_3$
   - Solution III: $Zn(NO_3)_2$

   A. Solution 1 only

   B. Solution II only

   C. Solutions I and II only

   D. Solutions I, II and III

Consider the Activity Series of metal. Fe>Ag so will displace it out of solution.
K and Zn are both > Fe

9. What mass of aluminium chloride ($AlCl_3$) is required to prepare a 500mL solution with concentration of 0.050 mol L^{-1}?

   A. 1.6 g

   B. 2.4 g

   C. 3.3 g

   D. 4.9 g

$V = 500 \text{ mL} = 0.500 \text{ L}$
$c = 0.050 \text{ mol L}^{-1}$
$m(AlCl_3) = ?$
$n = cV$
$= 0.500 \times 0.050$
$= 0.025 \text{ mol}$
$MM(AlCl_3) = 133.33 \text{ g mol}^{-1}$
$m = n \times MM$
$= 0.025 \times 133.33$
$= 3.33325$
$= 3.3 \text{ g}$

10. Which of the following statements about catalysts is NOT true?

A. provides an alternate reaction pathway

B. alters the overall enthalpy change ΔH of a reaction

C. reduces the activation energy E_a of a reaction

D. is not consumed during a reaction

Correct answer B: is not a true statement and is therefore the required response. Catalysts do not change the overall enthalpy change, ΔH, of a reaction; they only lower the activation energy, E_a.
A, **C** and **D** are true statements and are therefore not the required response.

11. When calcium carbonate ($CaCO_3$) is heated, it decomposes into calcium oxide and carbon dioxide according to the following reaction:

$$CaCO_3(s) \rightarrow CaO(s) + CO_2(g) \quad \Delta H = +178.3 \text{ kJ}$$

How much energy is required to decompose 21.34 g of $CaCO_3$?

A. 178.3 J

B. 17.83 kJ

C. 38.02 kJ

D. 89.00 kJ

$m(CaCO_3) = 21.34$ g

$MM(CaCO_3) = 100.09$ g mol^{-1}

$$n(CaCo_3) = \frac{m}{MM}$$
$$= \frac{21.34}{100.09}$$
$$= 0.2132 \text{ mol}$$

1 mol of $CaCO_3$ requires 178.3 kJ of energy.

0.2132 mol of $CaCO_3$ requires x kJ of energy.

$x = 0.2132 \times 178.3$

$= 38.02$ kJ

12. Strips of magnesium metal are placed in a beaker with dilute nitric acid. Which of the following will increase the rate of the reaction?

A. Increasing the pressure

B. Decreasing the volume of the nitric acid

C. Increasing the size of the magnesium strips

D. Increasing the concentration of the nitric acid

D is correct. Increasing the concentration of the nitric acid will increase the rate of reaction as there will be more reactant particles present, which will result in more successful collisions.
A and **B** are incorrect. Changes in pressure and in the volume of the solution will not change the reaction rate.
C is incorrect. Larger particle size will result in a slower reaction rate.

13. Given the following data:

$C_{(s)} + O_{2(g)} \rightarrow CO_{2(g)}.$ $\Delta = -393$ kJ mol^{-1}

$2H_{2(g)} + O_{2(g)} \rightarrow 2H_2O_{(g)}$ $\Delta = -484$ kJ mol^{-1}

$6C_{(s)} + 6H_{2(g)} + 3O_{2(g)} \rightarrow C_6H_{12}O_{6(s)}$ $\Delta = -984$ kJ mol^{-1}

Calculate the enthalpy change for the combustion of 1 mole of glucose in the equation:

$C_6H_{12}O_{6(s)} + 6O_{2(g)} \rightarrow 6CO_{2(g)} + 6H_2O_{(g)}$

A. -1413kJ

B. -2139kJ

C. -2397kJ

D. -2826kJ

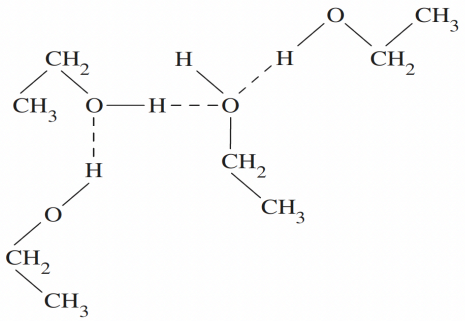
$6C_{(s)} + 6O_{2(g)} \rightarrow 6CO_{2(g)}$. $\Delta = 6 \text{ X } -393 \text{ kJ mol}^{-1}$

$6H_{2(g)} + 3O_{2(g)} \rightarrow 6H_2O_{(g)}$ $\Delta = 3 \text{ X } -484 \text{ kJ mol}^{-1}$

$C_6H_{12}O_{6(s)} \rightarrow 6C_{(s)} + 6H_{2(g)} + 3O_{2(g)}$ $\Delta = 984 \text{ kJ mol}^{-1}$

$C_6H_{12}O_{6(s)} + 6O_{2(g)} \rightarrow 6CO_{2(g)} + 6H_2O_{(g)}$ $\Delta = -2358 + -1452 + 984 = -2826 \text{ kJ mol}^{-1}$

14. The dashed lines in the diagram illustrate the bonds between some molecules.



What type of bonding do the dashed lines represent?

A. Hydrogen bonding

B. Dispersion forces

C. Intramolecular forces

D. Ion-dipole forces

A is correct. The diagram shows hydrogen bonding between molecules of ethanol. An ethanol molecule is polar, and the hydrogen atom attached to the oxygen atom can undergo hydrogen bonding with an oxygen atom in another ethanol molecule.

B is incorrect. Dispersion forces are present between non-polar molecules.

C is incorrect. Intramolecular forces hold the atoms in a molecule together; they do not hold molecules together.

D is incorrect. Ion–dipole forces are present between an ion and a molecule that has a dipole.

15. In which of the following reactions does entropy decrease?

A. $NH_4Cl(s) \rightarrow NH_3(g) + HCl(g)$

B. $NaCl(s) \rightarrow Na^+(aq) + Cl^-(aq)$

C. $N_2(g) + 2H_2(g) \rightarrow N_2H_4(l)$

D. $C_2H_5OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(g)$

Correct Answer is C

C is correct. In this reaction, 3 mol of gas converts to 1 mol of liquid. There is more order in the liquid state; therefore, entropy decreases.

A is incorrect. In this reaction, 1 mol of solid converts to 2 mol of gas. There is less order in the gas state; therefore, entropy increases.

B is incorrect. In this reaction, a solid is dissolving. Entropy increases in dissolutions.

D is incorrect. In this reaction, 3 mol of gas converts to 4 mol of gas. There is less order as more gas is produced; therefore, entropy increases.

Question 16 (6 marks)
Chemical Bonds are forces that hold atoms together. Complete the table.
Use IUPAC naming conventions.

Substance name	Substance formula	Bonding present within substance
Dinitrogen pentoxide	N_2O_5	covalent
nitrogen gas	N_2	covalent
Ammonium sulfate	$(NH_4)_2SO_4$	Covalent and ionic (**½ mark total for both)**
aluminium carbonate	$Al_2(CO_3)_3$	Covalent and ionic (**½ mark total for both)**
Sulfur trioxide	SO_3	covalent
silicon dioxide	SiO_2	covalent

Marking Criteria	Marks
• States correct name and bonding present including covalent and ionic for both ammonium sulfate and aluminium carbonate (1/2 mark for each response)	**6**
• subtract ½ for each additional mistake	**½ - 5½**

Marker's Comment: Generally done well but a number of students have not spent much time on this vital part of the course.

Question 17 (3 marks)
Hydrogen gas and chlorine gas react to form hydrogen chloride gas $HCl_{(g)}$ according to the following equation: $H_{2(g)} + Cl_{2(g)} \rightarrow 2HCl_{(g)}$
Calculate the mass of Cl_2 that would be required to produce 267g of HCl.

Marking Criteria	Marks

• Calculates the number of moles HCl AND • Calculates the number of moles of Cl2 AND • Calculates the mass of Cl2	**3**
• Calculates the number of moles HCl AND • Calculates the number of moles of Cl2	**2**
• Some Relevant information	**1**

$m(\text{HCl}) = 267 \text{ g}$

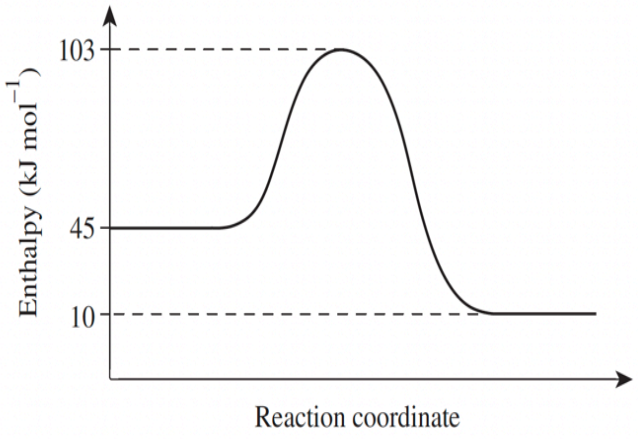
$$n(\text{HCl}) = \frac{m}{MM}$$
$$= \frac{267}{36.458}$$
$$= 7.3235 \text{ mol}$$

$$n(\text{Cl}_2) = n(\text{HCl}) \times \frac{1}{2}$$
$$= 7.3235 \times \frac{1}{2}$$
$$= 3.6617 \text{ mol}$$

$$m(\text{Cl}_2) = n \times MM$$
$$= 3.6617 \times 70.9$$
$$= 260 \text{ g}$$

Marker's Comment: Better answers recognised that no. moles must be determined to use the ratio in the balanced equation.

Question 18 (4 marks)
The energy profile diagram of the reaction between an aqueous solution of sodium hydroxide NaOH(aq) and sulfuric acid $H_2SO_{4(aq)}$ is shown.



(a) What is the activation energy in kJ mol^{-1} of this reaction? (1 mark)

Marking Criteria	Marks
• correctly calculates the activation energy	**1**

103-45 = 58kJ

(b) From the energy profile diagram, calculate the enthalpy change ΔH, for this reaction and explain whether the reaction is exothermic or endothermic. (2 marks)

Marking Criteria	Marks
• Identifies the energy of reactant and products AND • Calculates ΔH And • States the reaction is exothermic	2
• identifies the energy of reactant and products OR • Calculates ΔH OR • Explain the reaction is exothermic	1

The energy profile diagram shows that the reactants have greater energy (45 kJ mol–1) than the products (10 kJ mol–1). This means that the ΔH of the reaction is 10 – 45 = –35 kJ. Therefore, the reaction is exothermic.

Marker's Comment: Generally answered well, but some careless errors.

(c) In this reaction, the products are sodium sulfate and water. Write a balanced chemical formula equation for this reaction including the enthalpy value in kJ mol^{-1}.

(1 mark)

Marking Criteria	Marks
• correctly writes a balanced chemical reaction including enthalpy	1

$H_2SO_{4(aq)}$ + 2 NaOH(aq) → Na2SO4(aq) + 2 H2O(l) ΔH = -35kJ mol^{-1}

Marker's Comment: Most wrote equation well but some appeared confused as to how to show the enthalpy.

Question 19 (5 marks)

Marking Criteria	Marks
Describes the trends of metal reactivity down a group and across a period. AND Describes the trends of non-metal reactivity down a group and across a period. AND Describes the trends of electronegativity down a group and across a period. AND Describes the trends of atomic radii down a group and across a period. AND Describes the trends of first ionisation energy down a group and across a period	5
ALL of the above points with some errors OR All of the above missing one trend	4
Missing two trends	3

Sample Answer:

The reactivity of a metal refers to how readily it loses electrons. It increases down a group because the number of electron shells increases down a group, meaning electrons are not as strongly attracted to the nucleus. It decreases across a period as the increased core charge means electrons are less readily lost.

The reactivity of a non-metal refers to how readily it gains electrons. It decreases down a group as there are more electron shells, meaning electrons are gained less readily. It increases across a period due to the increased core charge making it easier to gain electrons.

Electronegativity is the measure of how strongly an atom attracts a pair of electrons to form a bond. It decreases down a group. This is because, moving down a group, valence electrons become further away from the nucleus and so are not as strongly attracted to the nucleus. Electronegativity increases across a period. Moving across a period, the number of occupied electron shells is constant; however, as core charge increases across a period, valence electrons become more attracted to the nucleus.

The atomic radius is a measure of the size of an atom. It increases down a group because the number of electron shells increases down a group. It decreases across a period because the number of occupied shells is constant across a period.

First ionisation energy is the amount of energy required to remove the outermost valence electron from an atom. It decreases down a group because the energy required to remove the electron decreases with increasing atom size, due to weaker attraction between valence electrons and the nucleus. First ionisation energy increases across a period. This is because core charge increases across a period, causing valance electrons to become more attracted to the nucleus, which means more energy is required to remove the outermost electron.

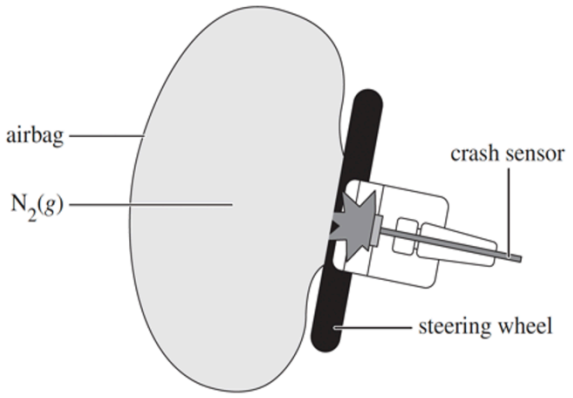
Marker's Comment: This was done well but some did not describe the trend vertically AND horizontally.

Question 20 (3 marks)

Modern cars are equipped with multiple airbags to protect occupants from sustaining injuries during a collision. On collision, the airbags are filled with nitrogen gas, which is produced by the reaction between sodium azide (NaN_3) and iron(III)oxide (Fe_2O_3).
The reaction occurs according to the following equation.

$$6NaN_{3(s)} + Fe_2O_{3(s)} \text{ ---> } 3Na_2O_{(s)} + 2Fe_{(s)} + 9N_{2(g)}$$

The diagram illustrates the airbag:



Calculate the mass of NaN_3, in grams, that is required to produce enough N_2 to fill an airbag that has a volume of 74.37L. Assume that the conditions are at 25°C and 100kPa.

Marking Criteria	Marks
Calculates the number of moles of N_2 using the Molar Volume formula. AND Calculates the number of moles of NaN_3 using stoichiometry. AND Calculates the mass of NaN_3	**3**
Calculates the number of moles of N_2 using the Molar Volume formula. AND Calculates the number of moles of NaN_3 using stoichiometry. •	**2**
• Any relevant steps	**1**

Sample Answer:
Using Molar Volume formula
At 25˚C and at 100kPa the volume of 1 mole of ideal gas occupies 24.79L =Vm
Find mol of the gas:
n=V/Vm
= 74.37/24.79 $molL^{-1}$
= 3 mol
Find mol : mol ratio

$$6NaN_{3(s)} + Fe_2O_{3(s)} \text{ ---> } 3Na_2O_{(s)} + 2Fe_{(s)} + 9N_{2(g)}$$
$$2 \qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad 3$$

Find mass:

n=m/mm
$m = n.mm_{NaN3}$
= 2 mol X (22.99 +14.01+14.01+14.01)
= 2 X 65.02
m = 130g

Marker's Comments: Done really well by most. You must show working.

Question 21 (8 marks)
A student conducted an experiment using a galvanic cell.One half cell comprised of an aluminium strip in aluminium nitrate solution Al(NO3)3(aq).The second half cell comprised of an iron strip in an iron(II)nitrate solution Fe(NO3)2(aq).

(a) Write the oxidation half equation. (1 Mark)

Marking Criteria	Marks
• correctly writes the oxidation equation including subscripts	**1**

$$Al(s) \rightarrow Al^{3+}(aq) + 3e^{-}$$

(b) Write the reduction half equation. (1 Mark)

Marking Criteria	Marks
• Correctly writes the reduction equation including subscripts	**1**

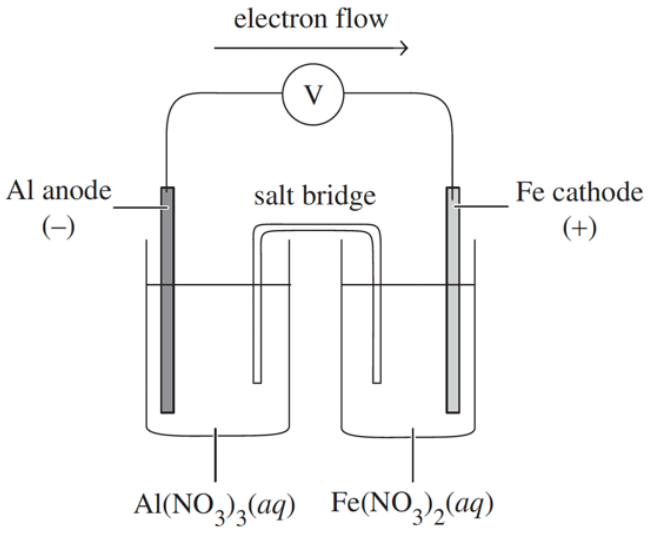
$$Fe^{2+}(aq) + 2e^{-} \rightarrow Fe(s)$$

Marker's Comments: Done well. Some careless mistakes- you MUST know how to write a half equation.

(c) Draw a fully labelled diagram of the galvanic cell used by the student. (5 Marks)

Include anode, cathode, direction of flow of electrons, salt bridge, direction of flow of ions. Label the electrolytes (solutions) in each cell.

Marking Criteria	Marks
• Draws a clear diagram AND • labels anode, cathode, direction of flow of electrons, salt bridge, direction of flow of ions and electrolytes (solutions) in each cell. •	**5**
• All of the above with a deduction of 1 =½ mark	



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

Marker's Comments: Done well. Some careless mistakes.

Remember, anions in the salt bridge flow toward the anode and cations in the salt bridge flow toward the cathode.

(d) Calculate the cell potential of the galvanic cell. (1 Mark)

Marking Criteria	Marks
• Correctly calculates the cell potential of the galvanic cell	1

$$\begin{aligned}&\text{cathode: Fe, } E^\circ = -0.44 \text{ V}\\&\text{anode: Al, } E^\circ = -1.68 \text{ V}\\&E^\circ_{\text{cell}} = E^\circ_{\text{cathode}} - E^\circ_{\text{anode}}\\&\quad = -0.44 - (-1.68)\\&\quad = 1.24 \text{ V}\end{aligned}$$

Marker's Comments: Done well.
Remember the voltage does not need to be multiplied.

Question 22 (6 marks)
The reaction between urea $CO(NH_2)_2$ and water occurs according to the following equation:

$$CO(NH_2)_{2(aq)} + H_2O_{(l)} \rightarrow CO_{2(g)} + 2NH_{3(g)}$$

Data about the reactants and products is shown in the table.

Substance	*Standard enthalpy of formation, ΔH_f° (kJ mol^{-1})*	*Standard entropy at 25°C and 100 kPa, ΔS° (J mol^{-1}K^{-1})*
carbon dioxide ($CO_2(g)$)	–393.5	213.6
urea ($CO(NH_2)_2(aq)$)	–319.2	173.8
water ($H_2O(l)$)	–285.9	69.96
ammonia ($NH_3(g)$)	–46.19	192.5

(i) Calculate Enthalpy Change ΔH for this reaction. (1 mark)

Marking Criteria	Marks
• Correctly calculates the Enthalpy Change ΔH	1

$$\begin{aligned}\Delta H^\circ_{\text{reaction}} &= \Sigma \Delta H_f^\circ(\text{products}) - \Sigma \Delta H_f^\circ(\text{reactants})\\&= \Sigma \Delta H_f^\circ\left[CO_2(g) + 2\left(NH_3(g)\right)\right] -\\&\qquad \Sigma \Delta H_f^\circ\left[\left(CO(NH_2)_2(aq)\right) + H_2O(l)\right]\\&= [-393.5 + 2\times(\ 46.19)] - [-319.2 + (-285.9)]\\&= 119.22 \text{ kJ mol}^{-1}\end{aligned}$$

Marker's Comments: Write a formula - it will help you with your working and signs.

Many careless mistakes.

(ii) Calculate the Entropy Change ΔS for this reaction. (1 mark)

Marking Criteria	Marks
• Correctly calculates Entropy Change ΔS	1

$$T = 25°C = 298.15\ K$$
$$\Delta S°_{reaction} = \Sigma\Delta S°(products) - \Sigma\Delta S°(reactants)$$
$$= \Sigma\Delta S°\left[CO_2(g) + 2(NH_3(g))\right] -$$
$$\Sigma\Delta S°\left[(CO(NH_2)_2(aq)) + H_2O(l)\right]$$
$$= (213.6 + 2\times192.5) - (173.8 + 69.96)$$
$$= 354.84\ J\ mol^{-1}\ K^{-1}$$
$$= 0.35484\ kJ\ mol^{-1}\ K^{-1}$$

Marker's Comments: Many lost an easy mark. Write the formula!

(iii) Using your calculations from (i) and (ii) and the table of data, calculate the Gibbs Free Energy $\Delta G°$ of the reaction and state whether the reaction is spontaneous. (2 marks)

Marking Criteria	Marks
• Correctly calculate the Gibbs Free Energy $\Delta G°$ of the reaction and • state whether the reaction is spontaneous.	2
• Correctly calculate the Gibbs Free Energy $\Delta G°$ of the reaction • OR • states whether the reaction is spontaneous with reason	1

$$\Delta G° = 119.22 - 298.15\times0.35484$$

ΔG= +13.42kJmol^{-1}
Since $\Delta G°$ >0 then reaction is non-spontaneous.

Marker's Comments: You had to convert 25˚C to K (25+273) AND convert the ΔS value in J/mol/k to KJ/mol/k by dividing by 1000 to get the mark.

COE was considered and a mark was awarded if the working was correct.

Non-spontaneous =1 mark

(iv) In an exothermic reaction with a negative entropy, explain the effect on the spontaneity of this reaction if the temperature is increased? (2 marks)

Marking Criteria	Marks
Identifies that ΔG° will be non-spontaneous or more positive EXPLAIN why …….AND as the temperature increases TΔS becomes more positive and the reaction becomes LESS spontaneous/non-spontaneous •	2
• One of the above	1

If exothermic then ΔH <0 and if ΔS<0 then -TΔS is a positive value.

If T increases -TΔS increases making the ΔG value more positive.
Therefore, Spontaneity is reduced.

entropy is becoming more ordered. increasing the temp
For a reaction to be spontaneous the ΔG° <0, therefore temperature must be greater than 336K.

OR

A negative ΔH value is favourable; however ΔS being negative (less entropy) is not. If at any point, -TΔS is > ΔH where ΔS is <0 and ΔH <0, the reaction will no longer be spontaneous. Hence by increasing the temp, -TΔS will get larger and the reaction will be less spontaneous as it will exceed the ΔH value and ΔG will be more positive.

Question 23 (4 marks)

Cryolite is an ore of aluminium and its formula is Na_3AlF_6.

(a) Calculate the molar mass of Na_3AlF_6.
(1 mark)

Marking Criteria	Marks
• correctly calculate the molar mass of Na_3AlF_6	1

mm Na_3AlF_6 = 68.97 + 26.98 + 114 = 209.95

Markers Comments: Well done. Easy marks do not round up.

(b) Calculate the percentage composition of each element by mass in Na_3AlF_6. (3 marks)

Marking Criteria	Marks

Calculates the correct percentage composition of all THREE elements in Na_3AlF_6	**3**
Calculates the percentage composition of all TWO elements in Na_3AlF_6 OR Calculates correctly the percentages but does not add up to 100%	**2**
Calculates the percentage composition of all ONE elements in Na_3AlF_6	**1**

$$\%Na = \frac{3\times 22.99}{209.95}\times 100$$
$$= 32.85\%$$

$$\%Al = \frac{26.98}{209.95}\times 100$$
$$= 12.85\%$$

$$\%F = \frac{6\times 19.00}{209.95}\times 100$$
$$= 54.30\%$$

Markers Comment:
Needs to add up to 100% so any rounding must be carefully considered

Question 24 (3 marks)

A student mixed 2mL each of aqueous solutions of silver nitrate and calcium chloride.

Anion	*Formula*	*Cation*	
		Soluble	***Insoluble***
nitrates	NO_3^-	all	
acetates	CH_3COO^-	all	
chlorides	Cl^-	most	Ag^+, Pb^{2+}
sulfates	SO_4^{2-}	most	Ba^{2+}, Ca^{2+}, Pb^{2+}, Ag^+
sulfides	S^{2-}	Group 1, NH_4^+, Group 2	most
hydroxides	OH^-	Group 1, NH_4^+, Ba^{2+}	most
carbonates	CO_3^{2-}	Group 1, NH_4^+	most

Use the solubility table above to complete the following equations using subscripts.

(i) Complete the word equation: (1 mark)

Marking Criteria	Marks
• Write both products	**1**

Silver nitrate + calcium chloride → silver chloride + calcium nitrate

Markers Comments: well done.

(ii) Write the neutral species formula equation: (1 mark)

Marking Criteria	Marks
• Writes a correct balanced equation with subscripts	**1**

Always balance your equation- you will not get the mark if this is not done.
Always use subscripts. This question is assessing whether you can read a solubility table.
No subscrits or incorrect subscript = 0 marks

$2AgNO_{3(aq).} + CaCl_{2(aq)} \rightarrow 2AgCl_{(s)} + Ca(NO_3)_{2(aq)}$

_____ + _____ _____ + _____

(iii) Write the net ionic formula equation that occurs: (1 mark)

Marking Criteria	Marks
• Writes a correct ionic equation with subscripts	1

Markers Comments:
Must have subscripts and must be net ionic.
Many of you took kept the '2' in front on each which should not be there.

$Ag^{+}_{(aq)} + Cl^{-}_{(aq)} \rightarrow AgCl_{(s)}$

Question 25

The heat of combustion of different alcohols are shown in the table.

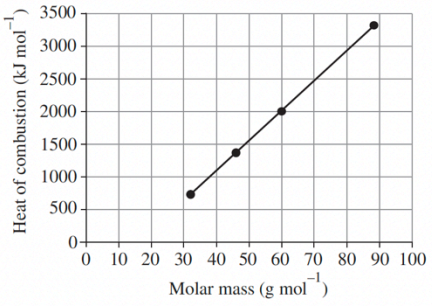
(a) Using data from the table, plot a graph showing the relationship between the molar mass and $\Delta_c H$ of the alcohol on the grid on the next page. Use a line of best fit.
(2 marks)

Marking Criteria	Marks
• correctly plots a graph showing the relationship between the molar mass and $\Delta_c H$ of the alcohol on the grid AND • Use a line of best fit.	2
• correctly plots a graph (with minor errors) showing the relationship between the molar mass and $\Delta_c H$ of the alcohol on the grid AND • Use a line of best fit. **OR** • correctly plots a graph (with/without minor errors) showing the relationship between the molar mass and $\Delta_c H$ of the alcohol on the grid AND • Does NOT Use a line of best fit.	1

(a) The molar masses of the alcohols are:

- methanol, $CH_3OH = 32.042\ g\ mol^{-1}$
- ethanol, $C_2H_5OH = 46.068\ g\ mol^{-1}$
- propan-1-ol, $C_3H_7OH = 60.094\ g\ mol^{-1}$
- pentan-1-ol, $C_5H_{11}OH = 88.146\ g\ mol^{-1}$

Relationship between molar mass and heat of combustion



Markers Comments: VERY EASY graphing question!
Use

- a scale that can be easily interpreted buy you and the marker. Many points were incorrectly plotted because you could not interpret your scale correctly
- all the graph paper.
- a lead pencil and then go over it with a black pen
- Put a zero for x and y axis
- use a ruler for line of best fit. Line of best fit should go through as many points as possible with any outliers fairly treated.
- mark your points with a cross

Some very messy graphs!

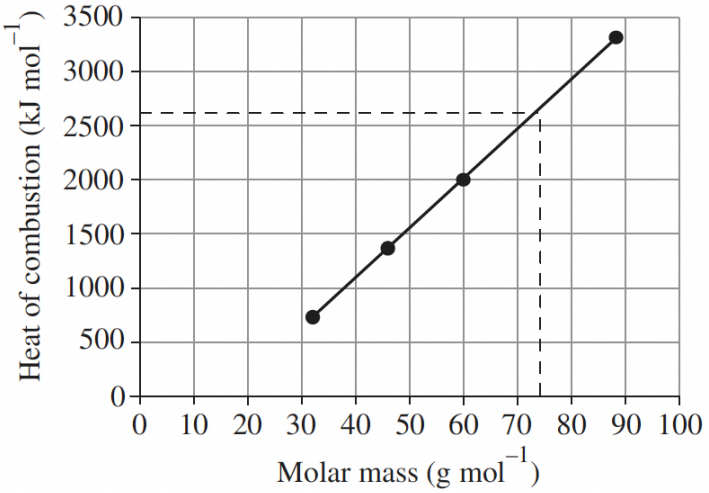
(b) Using the graph, mark on the graph the Heat of Combustion for butanol (C_4H_9OH) in kJ mol^{-1}. (1 mark)

Marking Criteria	Marks
• Correctly uses the graph, to mark on the the Heat of Combustion for butan-1-ol	**1**

(b) The molar mass of butan-1-ol, C_4H_9OH is 74.12 g mol^{-1}.

Based on the line of best fit, the heat of combustion, $\Delta_c H$, of butan-1-ol is 2670 kJ mol^{-1}.

Relationship between molar mass and heat of combustion



Reading from the graph, the $\Delta_c H$ of butan-1-ol is 2670 kJ mol^{-1}.

Note: Accept responses in the range 2625–2685 kJ mol^{-1}.

Markers Comments:
Show your calculation for molar mass of propanol.
Use a dotted line from the molar mass to the line of best fit. Then extend the dotted line to the y axis to show the Molar Heat of Combustion for butanol.

Question 26 (3 marks)

Analysis has shown that caffeine contains 49.5% carbon, 5.2% hydrogen, 28.7% nitrogen and 16.6% oxygen by mass.

(a) Calculate the Empirical formula of caffeine (2 marks)

Marking Criteria	Marks
• Calculate and shows working for the Empirical formula of caffeine	**2**
• Show at least one relevant step	**1**

$$49.5\%\ \text{C}: \frac{49.5}{12.01} = 4.12$$

$$5.2\%\ \text{H}: \frac{5.2}{1.008} = 5.2$$

$$28.7\%\ \text{N}: \frac{28.7}{14.01} = 2.05$$

$$16.6\%\ \text{O}: \frac{16.6}{16.00} = 1.04$$

Therefore, the empirical formula is $C_4H_5N_2O$

To check further then divide all by lowest, i.e. 1.04 to get

C : H : N : O
3.96 : 5.2 : 1.97 : 1.04

Markers comments:
All working out needs to be shown. Marks are lost for no working shown.

(b)If the molar mass is 194.19g mol-1, calculate the molecular formula. (1 mark)

Marking Criteria	Marks
• correctly calculate the molecular formula.	1

Therefore, the empirical formula is $C_4H_5N_2O$
($MM = 97.1$ g mol^{-1}).

As the molar mass of caffeine is 194.19 g mol^{-1}, the molecular formula is $C_8H_{10}N_4O_2$.

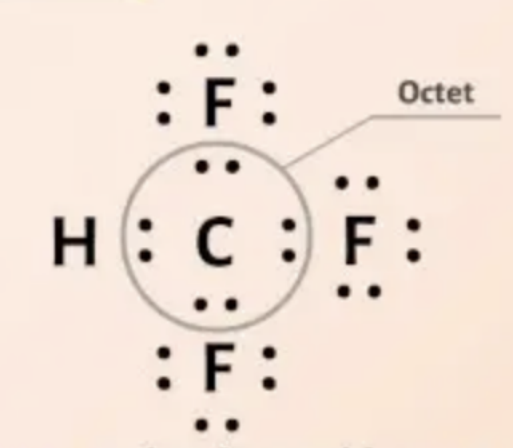
Question 27 (4 marks)
The boiling points and appropriate molecular masses of three fluorine containing compounds are shown in the table below.

Formula	HF	BF_3	CHF_3
Approximate molar mass	19	68	70
Boiling point (°C)	19.5	-100	-82.1

(a) Draw an electron dot formula diagram for CHF_3. (1 mark)

27(a)

Marking Criteria	Marks
• Draws an electron dot diagram for CHF_3 and identifies the shape of the molecule.	1



Markers Comments: Generally well done however many forgot to include all electrons in outer shell for F.

(b) Account for the differences in the boiling points of these three compounds. (3 marks)

27(b)

Marking Criteria	Marks
• Accounts for the differences in the boiling points of the **THREE** molecules by relating to the main type of intermolecular forces in each	**3**
• Accounts for the differences in the boiling points of the **TWO** molecules by relating to the main type of intermolecular forces in each	**2**
• Provides some relevant information.	**1**

Sample Answer:
HF has the lowest molecular mass and, on this basis, has the weakest dispersion forces. Its high boiling point cannot be due to dispersion forces. HF is a linear, polar molecule and has a H attached to a highly electronegative element (F). This makes the HF bond quite polar, and the molecule has a permanent dipole, with the F end being quite negative. A strong type of IMF called hydrogen bonds can form between H of one molecule and F of a neighbouring molecule. Hence the high boiling point.

BF_3 is a non-polar molecule because the bond dipoles cancel due to the symmetrical arrangement of the electron pairs around the B atom (due to its trigonal planar shape). It only has dispersion forces-temporary forces very weak in small molecules. Hence it has the lowest boiling point.

CHF_3 has 4 electron groups around the central C atoms, and it has a tetrahedral molecule. The molecule is polar because the more electronegative F atoms have a permanent -ve charge and the H atoms a permanent +ve charge. This type of molecule also has dipole-dipole interactions as well as dispersion forces. The dispersion forces in both molecules are the same in strength (similar masses), it must thus be the permanent dipole-dipole interactions that result in its higher boiling point.

Question 28 (3 marks)
A group of students carried out an investigation into energy changes that take place when sodium hydroxide solid NaOH(s) dissolves in water. A polystyrene cup was used as a calorimeter and a digital thermometer was used to take the 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
3. The temperature recorded every 20 seconds.
4. 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.
5. The results of the experiment are graphed below.

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Use the data in the graph to calculate the Molar Heat of Dissolution.

Marking Criteria	Marks
• Correctly calculates q AND • correctly calculates mol of NaOH AND • Correctly calculates Molar Heat of dissolution	**3**
• All of the above with no more than 2 minor errors	**2**
• Any relevant information	**1**

q=mCΔT

= (100.0 +5.0)g X 4.18 J g-1K-1 X 15K

= 6583.5J —----------1 mark

nNaOH = m/mm

= 5.0/39.998gmol-1

= 0.125 mol —----------1 mark

ΔH = q/n

= 6583.5J / 0.125 mol

= 52668 J mol-1

= 52.7 kJ mol-1 —----------1 mark

Markers Comments:
Important to set out the 3 steps
Change in temperature is the highest final temperature - initial temperature 32-17 = 15

Remember to add the solute to the mass of water

q=mCΔT

= (100.0 +**5.0)**g X 4.18 J g-1K-1 X 15K

= 6583.5J —----------1 mark