2021 ASSESSMENT MATERIALS

A- level Chemistry

Physical Chemistry

Total number of marks: 55

0 7 The melting point of XeF_4 is higher than the melting point of PF_3

Explain why the melting points of these two compounds are different.

In your answer you should give the shape of each molecule, explain why each molecule has that shape and how the shape influences the forces that affect the melting point.

[6 marks]

_____

_____

0 4 Compounds **A** and **B** react together to form an equilibrium mixture containing compounds **C** and **D** according to the equation

$$2\mathbf{A} + \mathbf{B} \rightleftharpoons 3\mathbf{C} + \mathbf{D}$$

0 4 . 1 A beaker contained 40 cm^3 of a 0.16 mol dm^{-3} aqueous solution of **A**.
9.5×10^{-3} mol of **B** and 2.8×10^{-2} mol of **C** were added to the beaker and the mixture was left to reach equilibrium.
The equilibrium mixture formed contained 3.9×10^{-3} mol of **A**.

Calculate the amounts, in moles, of **B**, **C** and **D** in the equilibrium mixture.

[5 marks]

Amount of **B** _____ mol

Amount of **C** _____ mol

Amount of **D** _____ mol

0 4 . 2 Give the expression for the equilibrium constant (K_c) for this equilibrium **and** its units.

[2 marks]

K_c

Units _____

0 4 . 3 A different equilibrium mixture of these four compounds, at a different temperature, contained 0.21 mol of **B**, 1.05 mol of **C** and 0.076 mol of **D** in a total volume of 5.00×10^2 cm^3 of solution.
At this temperature the numerical value of K_c was 116

Calculate the concentration of **A**, in mol dm^{-3}, in this equilibrium mixture.
Give your answer to the appropriate number of significant figures.

[3 marks]

Concentration of **A** _____ mol dm^{-3}

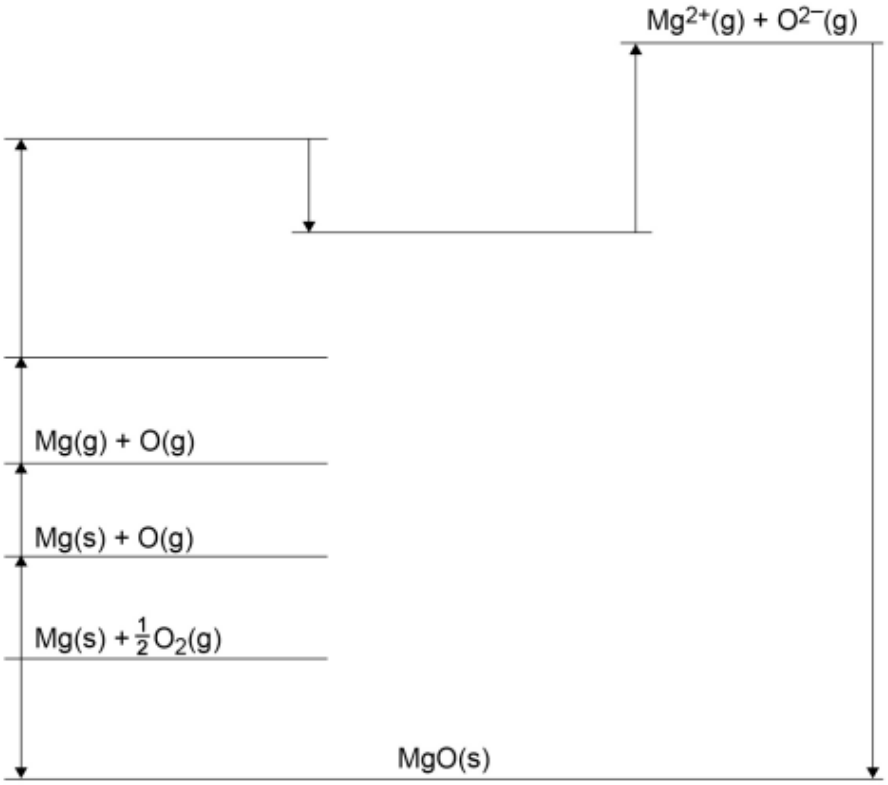
0 1 This question is about lattice enthalpies.

0 1 . 1 **Figure 1** shows a Born–Haber cycle for the formation of magnesium oxide.

Complete **Figure 1** by writing the missing symbols on the appropriate energy levels.

[3 marks]

Figure 1



0 1 . 2 **Table 1** contains some thermodynamic data.

Table 1

	Enthalpy change / kJ mol^{-1}
Enthalpy of formation for magnesium oxide	–602
Enthalpy of atomisation for magnesium	+150
First ionisation energy for magnesium	+736
Second ionisation energy for magnesium	+1450
Bond dissociation enthalpy for oxygen	+496
First electron affinity for oxygen	–142
Second electron affinity for oxygen	+844

Calculate a value for the enthalpy of lattice formation for magnesium oxide.

[3 marks]

Enthalpy of lattice formation _____ kJ mol^{-1}

0 3 The equation for the reaction between ammonia and oxygen is shown.

$$4NH_3(g) + 5O_2(g) \rightleftharpoons 4NO(g) + 6H_2O(g) \qquad \Delta H = -905 \text{ kJ mol}^{-1}$$

Some standard entropies are given in **Table 3**.

Table 3

Gas	$S^\ominus$ / J K^{-1} mol^{-1}
$NH_3(g)$	193
$O_2(g)$	205
$NO(g)$	211
$H_2O(g)$	189

0 3 . 1 Calculate the entropy change for the reaction between ammonia and oxygen.

[2 marks]

Entropy change _____ J K^{-1} mol^{-1}

0 3 . 2 Calculate a value for the Gibbs free-energy change (ΔG), in kJ mol^{-1}, for the reaction between ammonia and oxygen at 600 °C

(If you were unable to obtain an answer to Question **03.1**, you should assume that the entropy change is 211 J K^{-1} mol^{-1}. This is **not** the correct answer.)

[2 marks]

ΔG _____ kJ mol^{-1}

0 3 . 3 The reaction between ammonia and oxygen was carried out at a higher temperature.

Explain how this change affects the value of ΔG for the reaction.

[2 marks]

_____

_____

_____

_____

_____

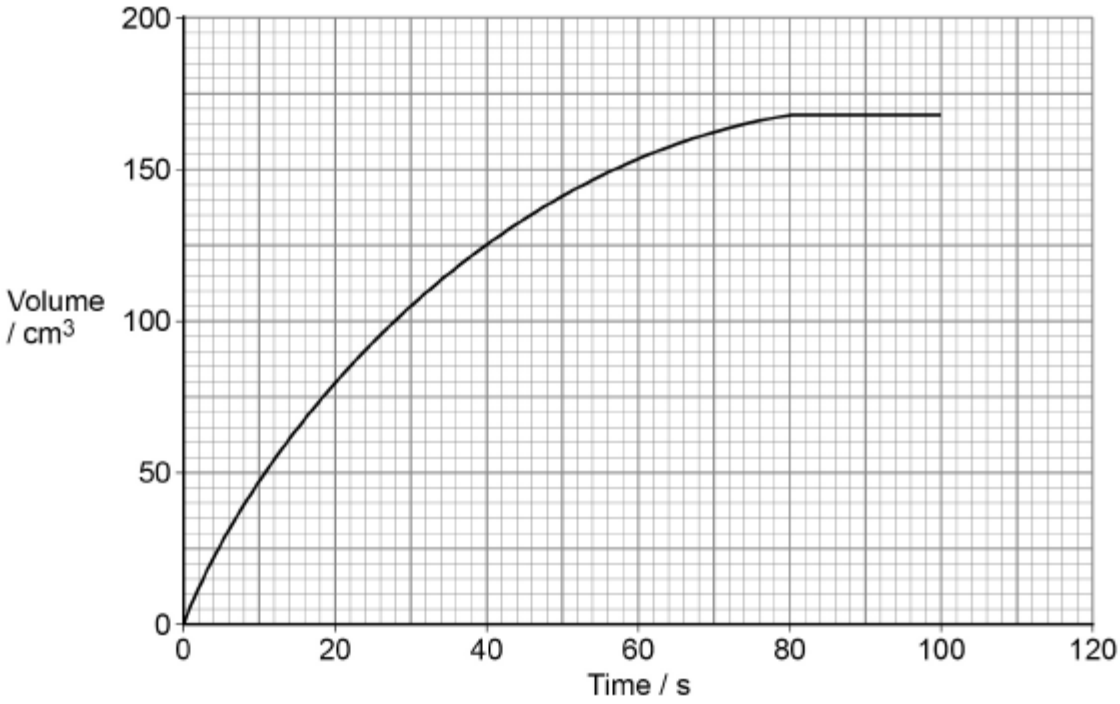
0 1 This question is about rates of reaction.

Phosphinate ions ($H_2PO_2^-$) react with hydroxide ions to produce hydrogen gas as shown.

$$H_2PO_2^- + OH^- \rightarrow HPO_3^{2-} + H_2$$

A student completed an experiment to determine the initial rate of this reaction.
The student used a solution containing phosphinate ions and measured the volume of hydrogen gas collected every 20 seconds at a constant temperature.
Figure 1 shows a graph of the student's results.

Figure 1



0 1 . 1 Use the graph in **Figure 1** to determine the initial rate of reaction for this experiment. State its units. Show your working on the graph.

[3 marks]

Rate _____ Units _____

0 1 . 2 Another student reacted different initial concentrations of phosphinate ions with an excess of hydroxide ions. The student measured the time (t) taken to collect 15 cm^3 of hydrogen gas. Each experiment was carried out at the same temperature. **Table 1** shows the results.

Table 1

Initial $[H_2PO_2^-]$ / mol dm^{-3}	t / s
0.25	64
0.35	32
0.50	16
1.00	4

State the relationship between the initial concentration of phosphinate and time (t).

Deduce the order of the reaction with respect to phosphinate.

[2 marks]

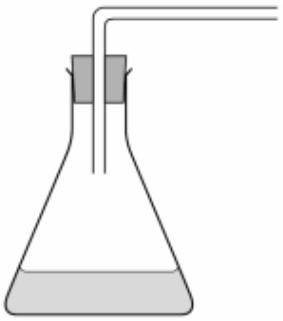
Relationship _____

Order _____

0 1 . 3 Complete the diagram in **Figure 2** to show how the hydrogen gas could be collected and measured in the experiments in Questions **01.1** and **01.2**.

[1 mark]

Figure 2



The rate equation for a different reaction is

$$rate = k\,[L]\,[M]^2$$

0 1 . 4 Deduce the overall effect on the rate of reaction when the concentrations of both **L** and **M** are halved.

[1 mark]

0 6 Standard electrode potentials are measured by comparison with the standard hydrogen electrode.

0 6 . 1 State the substances and conditions needed in a standard hydrogen electrode.

[3 marks]

0 6 . 4 **Table 2** shows some electrode potential data.

Table 2

Electrode reaction	$E^{\ominus}$ / V
$2H^+(aq) + 2e^- \rightarrow H_2(g)$	0.00
$Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$	+0.34
$NO_3^-(aq) + 4H^+(aq) + 3e^- \rightarrow NO(g) + 2H_2O(l)$	+0.96

Use the data in **Table 2** to explain why copper does **not** react with most acids but does react with nitric acid.

Give an equation for the reaction between copper and nitric acid.

[3 marks]

Explanation _____

_____

_____

_____

_____

Equation

_____

0 2 This question is about sulfuric acid and its salts.

0 2 . 2 In aqueous solution, sulfuric acid acts as a strong acid. The H_2SO_4 dissociates to form HSO_4^- ions and H^+ ions.

The HSO_4^- ions act as a weak acid and dissociate to form SO_4^{2-} ions and H^+ ions.

Give an equation to show each stage in the dissociation of sulfuric acid in aqueous solution.

Include appropriate arrows in your equations.

[2 marks]

Equation 1 _____

Equation 2 _____

0 2 . 4 A solution that contains 605 mg of $NaHSO_4$ in 100 cm^3 of solution has a pH of 1.72

Calculate the value of K_a for the hydrogensulfate ion (HSO_4^-) that is behaving as a weak acid.
Give your answer to three significant figures.

State the units of K_a

[6 marks]

K_a _____ Units _____

0 8 Which has a bond angle of 109.5°?

[1 mark]

A C (diamond) ⬭

B C (graphite) ⬭

C NH_2^- ⬭

D NH_3 ⬭

1 3 Which statement about pH is correct?

[1 mark]

A The pH of a weak base is independent of temperature. ⬭

B At temperatures above 298 K, the pH of pure water is less than 7. ⬭

C The pH of 2.0 mol dm^{-3} nitric acid is approximately 0.30 ⬭

D The pH of 0.10 mol dm^{-3} sulfuric acid is greater than that of 0.10 mol dm^{-3} hydrochloric acid. ⬭

3 2 Which is the concentration of NaOH(aq), in mol dm^{-3}, that has pH = 14.30?

$K_w = 1.00 \times 10^{-14}$ mol^2 dm^{-6} at 25 °C

[1 mark]

A –1.16 ⬭

B 5.01×10^{-15} ⬭

C 2.00×10^{14} ⬭

D 2.00 ⬭

1 1 In which conversion is the metal reduced?

[1 mark]

A $Cr_2O_7^{2-} \rightarrow CrO_4^{2-}$ ⬭

B $MnO_4^{2-} \rightarrow MnO_4^-$ ⬭

C $TiO_2 \rightarrow TiO_3^{2-}$ ⬭

D $VO_3^- \rightarrow VO^{2+}$ ⬭

3 3 What are the units of the rate constant for a third order reaction?

[1 mark]

A mol dm^{-3} s^{-1} ⬭

B mol^{-1} dm^3 s^{-1} ⬭

C mol^2 dm^{-6} s^{-1} ⬭

D mol^{-2} dm^6 s^{-1} ⬭

3 4 What is the pH of 0.015 mol dm^{-3} sulfuric acid?

[1 mark]

A –1.82 ⬭

B –1.52 ⬭

C 1.52 ⬭

D 1.82 ⬭