

Candidate Marks Report

Series : 6 2018

This candidate's script has been assessed using On-Screen Marking. The marks are therefore not shown on the script itself, but are summarised in the table below.

Centre No :	Assessment Code :	H432
Candidate No :	Component Code :	01
Candidate Name :		

Total Marks : 48 / 100

In the table below 'Total Mark' records the mark scored by this candidate.
'Max Mark' records the Maximum Mark available for the question.

Paper: H432/01	
Paper 48 / 100	
Total:	
Question	Total / Max Mark / Mark
1	0 / 1
2	1 / 1
3	1 / 1
4	1 / 1
5	1 / 1
6	1 / 1
7	0 / 1
8	0 / 1
9	1 / 1
10	0 / 1
11	1 / 1
12	1 / 1
13	0 / 1
14	1 / 1
15	1 / 1
16ai	2 / 2
16aii	0 / 4
16aiii	0 / 2
16aiv	1 / 2
16bi	0 / 2
16bii	2 / 3
17a	2 / 6
17bi	2 / 3
17bii	2 / 2
18a	1 / 2
18b	4 / 4
18ci	0 / 1
18cii	2 / 3
19ai	1 / 1
19aii	2 / 3
19aiii	0 / 1

19b	4 / 4
19c	0 / 2
20a	0 / 3
20b	0 / 3
20c	1 / 4
20di	2 / 2
20dii	1 / 1
20diii	0 / 2
20div	0 / 5
21a	2 / 2
21bi	3 / 4
21bii	1 / 1
21ci	0 / 1
21cii	2 / 4
21d	1 / 6

SECTION A

You should spend a maximum of 20 minutes on this section.

Write your answer to each question in the box provided.

Answer all the questions.

- 1 A sample of boron contains the isotopes ^{10}B and ^{11}B .
The relative atomic mass of the boron sample is 10.8.

What is the percentage of ^{11}B atoms in the sample of boron?

- A 8.0%
B 20%
C 80%
D 92%

Your answer

A



[1]

$$+3 \cdot 1 + 5 = 10.8$$

- 2 In the compound $[\text{ICl}_2]^+ [\text{SbCl}_6]^-$, the oxidation number of chlorine is -1 .

What are the oxidation numbers of I and Sb in the compound?

	I	Sb
A	+1	+5
B	+1	+7
C	+3	+5
D	+3	+7

Your answer

C



[1]

- 3 What is the number of hydrogen atoms in 0.125 mol of $\text{C}_2\text{H}_5\text{OH}$?

- A 7.525×10^{22}
B 4.515×10^{23}
C 3.7625×10^{23}
D 3.612×10^{24}

$$2 \times 1 + 3 \times 1 + 1 = 6$$

$$\frac{0.125}{40} = 2.72 \times 10^{-3}$$

Your answer

B



[1]



- 4 A student titrates a standard solution of barium hydroxide, $\text{Ba}(\text{OH})_2$, with nitric acid, HNO_3 .
 25.00 cm^3 of $0.0450 \text{ mol dm}^{-3}$ $\text{Ba}(\text{OH})_2$ are needed to neutralise 23.35 cm^3 of $\text{HNO}_3(\text{aq})$.

What is the concentration, in mol dm^{-3} , of the nitric acid?

- A 0.0241
 B 0.0482
 C 0.0900
 D 0.0964

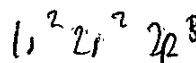
$$\begin{array}{l} 1 \quad 2 \\ n = 1.125 \times 10^{-3} \quad n = 2.25 \times 10^{-3} \\ c = 0.045 \quad c = 0.02335 \\ v = 25.00 \quad v = 23.35 \end{array}$$

Your answer

D

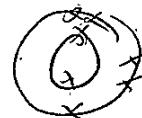


[1]



- 5 Which statement best explains why nitrogen has a larger first ionisation energy than oxygen?

- A N atoms have less repulsion between p-orbital electrons than O atoms.
 B N atoms have a smaller nuclear charge than O atoms.
 C N atoms lose an electron from the 2s subshell, while O atoms lose an electron from the 2p subshell.
 D N atoms have an odd number of electrons, while O atoms have an even number.



Your answer

A



[1]

2s

2p

- 6 In the Periodic Table, element X is in Group 2 and element Y is in Group 15 (5).

What is the likely formula of an ionic compound of X and Y?

- A X_2Y_5
 B X_2Y_3
 C X_3Y_2
 D X_5Y_2

Your answer

C



[1]



7 Which statement about ammonium carbonate is **not** correct?

- A It reacts with $\text{Ba}(\text{NO}_3)_2(\text{aq})$ to form a white precipitate.
- B It effervesces with dilute nitric acid. ✓
- C It release an alkaline gas with warm $\text{NaOH}(\text{aq})$. ✓
- D It has the formula NH_4CO_3 . ✓

Your answer

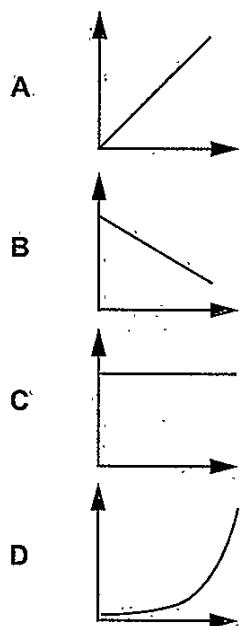
A



[1]

8 A reaction is first order with respect to a reactant X.

Which rate-concentration graph for reactant X is the correct shape?



Your answer:

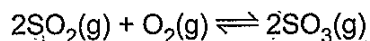
B



[1]



- 9 The reversible reaction of sulfur dioxide and oxygen to form sulfur trioxide is shown below.



An equilibrium mixture contains 2.4 mol SO_2 , 1.2 mol O_2 and 0.4 mol SO_3 .
The total pressure is 250 atm.

What is the partial pressure of SO_3 ?

$$\frac{0.4}{4} \times 250$$

- A 15 atm
B 25 atm
C 100 atm
D 200 atm

Your answer

B



[1]

- 10 A buffer solution is prepared by mixing 200 cm³ of 2.00 mol dm⁻³ propanoic acid, $\text{CH}_3\text{CH}_2\text{COOH}$, with 600 cm³ of 1.00 mol dm⁻³ sodium propanoate, $\text{CH}_3\text{CH}_2\text{COONa}$.

K_a for $\text{CH}_3\text{CH}_2\text{COOH} = 1.32 \times 10^{-5} \text{ mol dm}^{-3}$

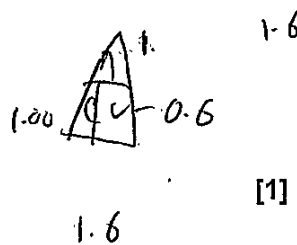
What is the pH of the buffer solution?

- A 4.58
B 4.70
C 5.06
D 5.18

$$1.32 \times 10^{-5}$$

$$K_a = \frac{[\text{H}^+]}{[\text{HA}]}$$

$$K_a = \frac{[\text{CH}_3\text{CH}_2\text{COO}^-]}{[\text{CH}_3\text{CH}_2\text{COOH}]}$$



Your answer

B



[1]

$$[\text{Na}^+] =$$

$$[\text{H}^+] =$$

$$K_a \times [\text{HA}]$$

$$2.112 \times 10^{-5}$$

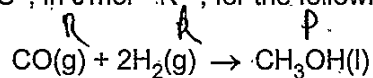
$$-\log($$



11 The table below shows standard entropies, S^\ominus .

Substance	CO(g)	H ₂ (g)	CH ₃ OH(l)
$S^\ominus/\text{J mol}^{-1}\text{K}^{-1}$	197.6	130.6	239.7

What is the entropy change, ΔS^\ominus , in $\text{J mol}^{-1}\text{K}^{-1}$, for the following reaction?



A -219.1

B -88.5

C +88.5

D +219.1

Your answer

A



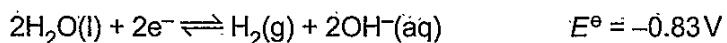
[1]

239.7

197.6

261.2 + 458.8

12 The redox equilibria for a hydrogen-oxygen fuel cell in alkaline solution are shown below.



What is the equation for the overall cell reaction?

A $\text{H}_2(\text{g}) + 4\text{OH}^-(\text{aq}) \rightarrow 3\text{H}_2\text{O}(\text{l}) + \frac{1}{2}\text{O}_2(\text{g})$

B $3\text{H}_2\text{O}(\text{l}) + \frac{1}{2}\text{O}_2 \rightarrow \text{H}_2(\text{g}) + 4\text{OH}^-(\text{aq})$

C $\text{H}_2\text{O}(\text{l}) \rightarrow \text{H}_2(\text{g}) + \frac{1}{2}\text{O}_2(\text{g})$

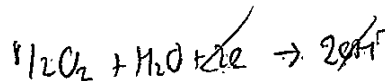
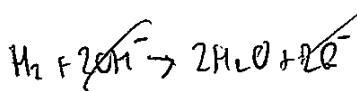
D $\text{H}_2(\text{g}) + \frac{1}{2}\text{O}_2(\text{g}) \rightarrow \text{H}_2\text{O}(\text{l})$

Your answer

D



[1]



13. Which enthalpy change(s) is/are endothermic?

- 1 The bond enthalpy of the C-H bond ✓
- 2 The second electron affinity of oxygen
- 3 The standard enthalpy change of formation of magnesium ✓

- A 1, 2 and 3
B Only 1 and 2
C Only 2 and 3
D Only 1

Your answer:

A

[1]



14. Which statement(s) explain(s) why reaction rates increase as temperature increases?

- 1 The activation energy is less. ✗
- 2 Collisions between molecules are more frequent.
- 3 A greater proportion of molecules have energy greater than the activation energy. ✓

- A 1, 2 and 3
B Only 1 and 2
C Only 2 and 3
D Only 1

Your answer:

C



[1]



15 Which statement(s) is/are correct for the complex $\text{Pt}(\text{NH}_3)_2\text{Cl}_2$?

- 1 One of its stereoisomers is used as an anti-cancer drug. ✓
- 2 It has bond angles of 109.5° .
- 3 It has optical isomers.

- A 1, 2 and 3
B Only 1 and 2
C Only 2 and 3
D Only 1

Your answer

0



[1]



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SECTION B

Answer all the questions.

16 This question is about enthalpy changes.

(a) Table 16.1 shows enthalpy changes that can be used to determine the enthalpy change of hydration of fluoride ions, F^- .

Enthalpy change	Energy/ kJ mol^{-1}
Hydration of Ca^{2+}	-1609
Solution of CaF_2	+13
Lattice enthalpy of CaF_2	-2630

Table 16.1

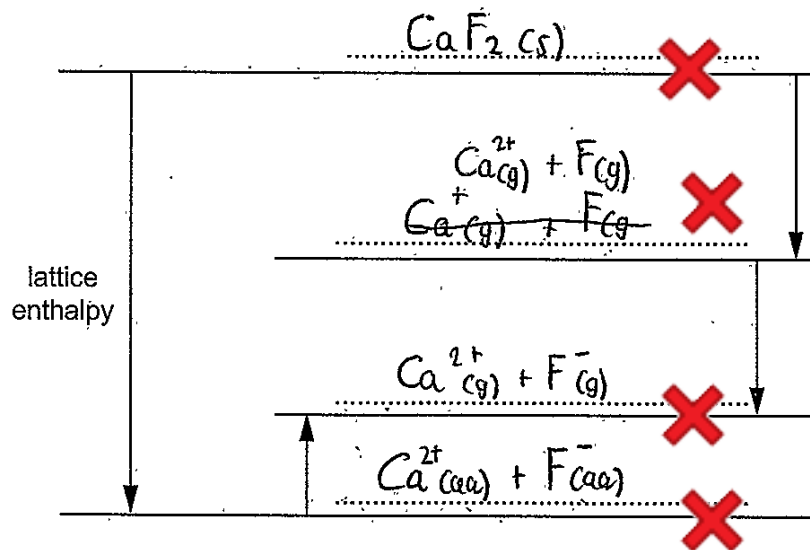
(i) Explain what is meant by the term *enthalpy change of hydration*.

The enthalpy change when 1 mole of gaseous ions is dissolved in water.

[2]

(ii) The enthalpy change of hydration of F^- can be determined using the enthalpy changes in Table 16.1 and the incomplete energy cycle below.

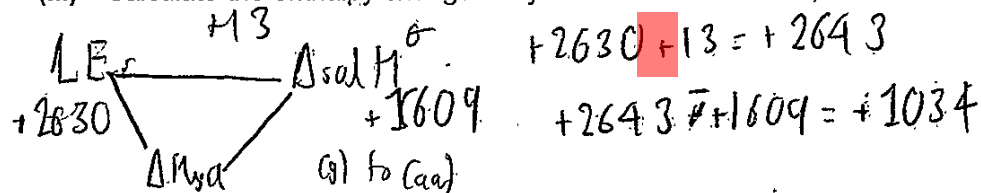
On the dotted lines, add the species present, including state symbols.

 Ca^{2+} 

[4]



(iii) Calculate the enthalpy change of hydration of fluoride ions, F^- .



enthalpy change of hydration = $+1034$ ~~mol⁻¹~~ [2]

(iv) Predict how the enthalpy changes of hydration of F^- and Cl^- would differ.

Atomic radius

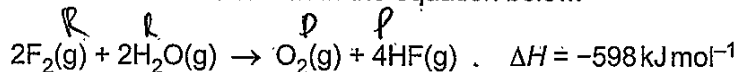
Explain your answer.

→ Atomic radius

The enthalpy change of hydration of F^- will be have a more negative value. This is because F^- has a greater attraction to water molecules. Therefore would require more energy to overcome. [2]



(b) Fluorine reacts with steam as shown in the equation below.



Average bond enthalpies are shown in the table:

Bond	Average bond enthalpy / kJ mol ⁻¹
O-H	+464
O=O	+498
H-F	+568

(i) Explain what is meant by the term *average bond enthalpy*.

Enthalpy change of 1 mol of gaseous atoms broken

Energy change when 1 mole of gaseous atoms are broken.

[2]

(ii) Calculate the bond enthalpy of the F-F bond.

$$4 \text{ H-F} = (4 \times 568) = 2272$$

Product =

$$\text{O}_2 = +498$$

$$\text{Reactants} = 2\text{H}_2\text{O} = (2 \times 464) + (2 \times 464) = 1856$$

$$\text{Product} = 2770 \quad 2770 - 1856 = 914 \quad -598 = \frac{316}{2} = +158$$

$$\text{Reactant} = 1856$$

$$2 = +79$$

bond enthalpy = +79 kJ mol⁻¹ [3]



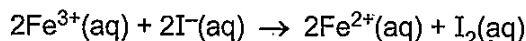
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17 This question is about reaction rates.

Aqueous iron(III) ions, $\text{Fe}^{3+}(\text{aq})$, react with aqueous iodide ions, $\text{I}^{-}(\text{aq})$, as shown below.



A student carries out three experiments to investigate how different concentrations of $\text{Fe}^{3+}(\text{aq})$ and $\text{I}^{-}(\text{aq})$ affect the initial rate of this reaction. The results are shown below.

Experiment	$[\text{Fe}^{3+}(\text{aq})]$ / mol dm^{-3}	$[\text{I}^{-}(\text{aq})]$ / mol dm^{-3}	Initial rate / $\text{mol dm}^{-3} \text{s}^{-1}$
1	4.00×10^{-2}	8.00×10^{-2}	8.10×10^{-4}
2	8.00×10^{-2}	3.00×10^{-2}	1.62×10^{-3}
3	4.00×10^{-2}	8.00×10^{-2}	3.24×10^{-3}

rate equation =

$$\text{Initial rate} = k [\text{Fe}^{3+}]^2 [\text{I}^{-}]^2$$

$$\text{cc } k = \frac{\text{rate}}{[\text{Fe}^{3+}]^2 [\text{I}^{-}]^2}$$

(a)* Determine the rate constant and a possible two-step mechanism for this reaction that are consistent with these results. [6]

$$\text{rate} = k [\text{Fe}^{3+}]^2 [\text{I}^{-}]^2$$

$$k = \frac{\text{rate}}{[\text{Fe}^{3+}]^2 [\text{I}^{-}]^2}$$

From experiments 1 and 2, when the concentration of $[\text{Fe}^{3+}(\text{aq})]$ doubles, the initial rate also doubles making the reaction first order with respect to $[\text{Fe}^{3+}(\text{aq})]$.

From experiments 1 and 3, when the concentration of $[\text{I}^{-}(\text{aq})]$ doubles, the initial rate ~~also~~ quadruples making the reaction second order with respect to $[\text{I}^{-}(\text{aq})]$.

$$\text{Rate constant} = \frac{8.10 \times 10^{-4}}{[4.00 \times 10^{-2}]^2 [8.00 \times 10^{-2}]^2} = 3.164$$

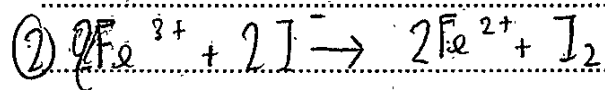
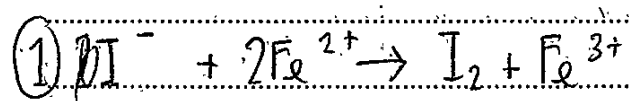
$$\frac{\text{mol dm}^{-3} \text{s}^{-1}}{(\text{mol dm}^{-3})^2 (\text{mol dm}^{-3})^2}$$

$$\text{dm}^6 \text{mol}^{-2} \text{s}^{-1}$$

Additional answer space if required



Two step mechanism: rate equation: $k = [\text{Fe}^{3+}] [\text{I}^-]^2$

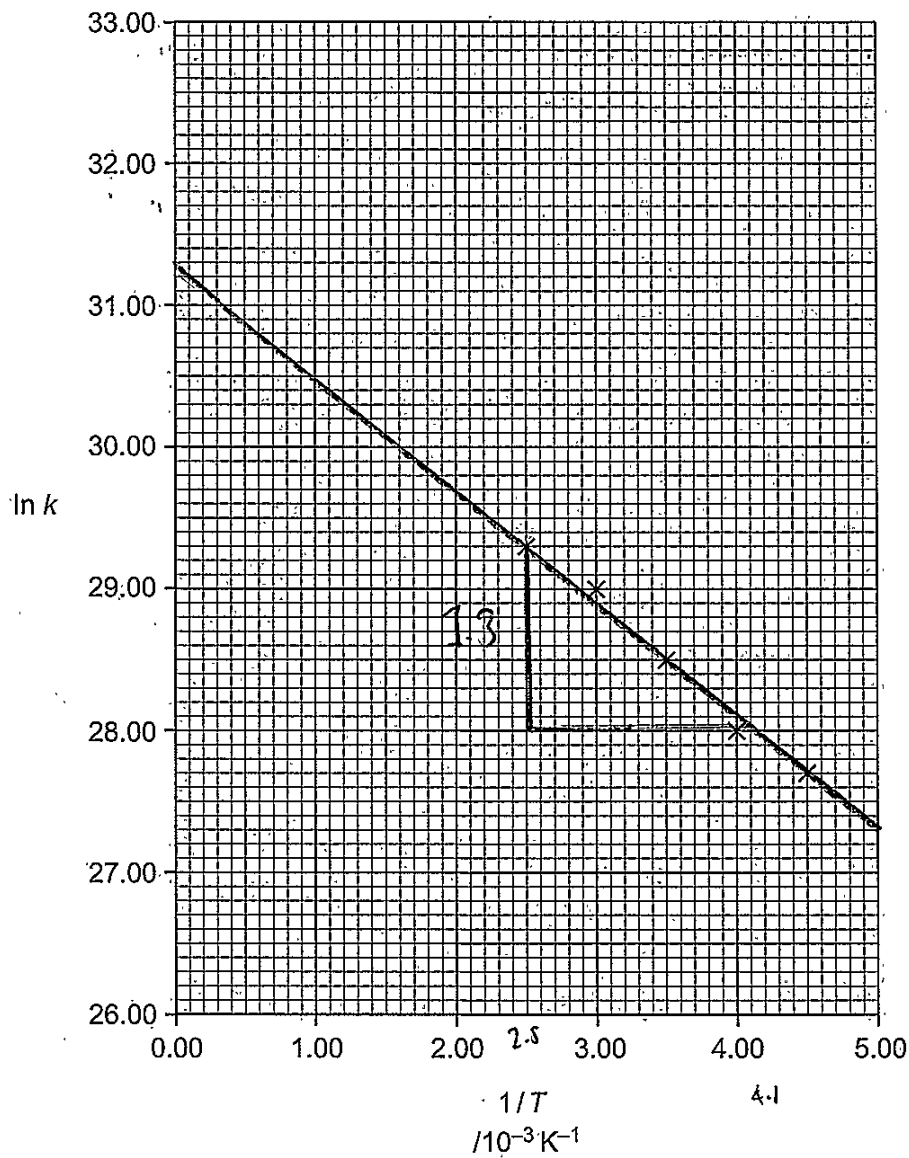


LI



- (b) A student carries out an investigation to find the activation energy, E_a , and the pre-exponential factor, A , of a reaction.

The student determines the rate constant, k , at different temperatures, T .
The student then plots a graph of $\ln k$ against $1/T$ as shown below:



- (i) Draw a best-fit straight line and calculate the activation energy, in J mol^{-1} .
Give your answer to **three significant figures**.

y = mx Show your working.

$$\ln k = -E_a / RT + \ln A$$

$$\ln k = -E_a / T$$

gradient

$$\frac{\Delta y}{\Delta x}$$

$$= \frac{1.3}{1.6} = 0.8125$$

$$E_a = \frac{\Delta y}{\Delta x} \times 8.314$$

$$0.8125 \times 8.314 = 6.755$$

activation energy, $E_a = + 6.755 \text{ J mol}^{-1}$ [3]

- (ii) Use the graph to calculate the value of the pre-exponential factor; A.

Show your working.

$$y \text{ intercept} = 81.3$$

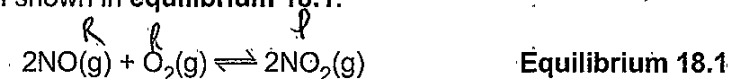
$$A = e^{y \text{ intercept}}$$

$$A = e^{81.3} = 3.92 \times 10^{13}$$

pre-exponential factor, A = 3.92×10^{13} [2]



- 18 Nitrogen monoxide, NO, and oxygen, O₂, react to form nitrogen dioxide, NO₂, in the reversible reaction shown in **equilibrium 18.1**.



- (a) Write an expression for K_c for this equilibrium and state the units.

$$K_c = \frac{[\text{NO}_2(\text{g})]^2}{[\text{NO}(\text{g})]^2 [\text{O}_2(\text{g})]}$$

$\frac{(\text{mol dm}^{-3}) (\text{mol dm}^{-3})}{(\text{mol dm}^{-3}) (\text{mol dm}^{-3}) (\text{mol dm}^{-3})}$

Units = ~~mol dm⁻³~~ ✓

[2]

- (b) A chemist mixes together nitrogen and oxygen and pressurises the gases so that their total gas volume is 4.0 dm³.

- The mixture is allowed to reach equilibrium at constant temperature and volume.
- The equilibrium mixture contains 0.40 mol NO and 0.80 mol O₂.
- Under these conditions, the numerical value of K_c is 45.

Calculate the amount, in mol, of NO₂ in the equilibrium mixture.

	2NO	O ₂	2NO ₂
Initial mol	0	0	0
Eqm mol	0.40	0.80	2.12
Eqm concentration	0.1	0.2	0.53

Concentration of NO₂
 $= \frac{2.12}{4} = 0.53 \text{ mol dm}^{-3}$

Concentration for NO = $\frac{0.40}{4} = 0.1 \text{ mol dm}^{-3}$

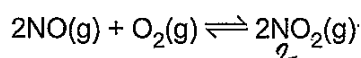
Concentration for O₂ = $\frac{0.80}{4} = 0.2 \text{ mol dm}^{-3}$

0.4

amount of NO₂ = ~~0.212~~ ✓✓✓ mol [4]



(c) The values of K_p for **equilibrium 18.1** at 298 K and 1000 K are shown below.



Equilibrium 18.1

Temperature / K	K_p / atm^{-1}
298	$K_p = 2.19 \times 10^{12}$
1000	$K_p = 2.03 \times 10^{-1}$

(i) Predict, with a reason, whether the forward reaction is exothermic or endothermic.

The forward reaction is exothermic as ~~bonds are~~
~~being made~~ $\text{NO}_2 + \text{O}_2$ bond together which releases [1]
 energy.

(ii) The chemist increases the pressure of the equilibrium mixture at the same temperature.

State, and explain in terms of K_p , how you would expect the equilibrium position to change.

An increase in pressure would produce more NO_2 .
 This is because as pressure increases, equilibrium
 will shift to the side with fewer gaseous moles
 which is the right hand ✓ in order to keep K_p constant. ✓

[3]



19 This question is about acids and bases found in the home.

(a) Ethanoic acid, CH_3COOH , is the acid present in vinegar.

A student carries out an experiment to determine the $\text{p}K_a$ value of CH_3COOH .

- The concentration of CH_3COOH in the vinegar is $0.870 \text{ mol dm}^{-3}$.
- The pH of the vinegar is 2.41.

(i) Write the expression for the acid dissociation constant, K_a , of CH_3COOH .

$$K_a = \frac{[\text{CH}_3\text{COO}^-][\text{H}^+]}{[\text{CH}_3\text{COOH}]}$$

[1]

(ii) Calculate the $\text{p}K_a$ value of CH_3COOH .

Give your answer to two decimal places.

$$\text{p}K_a = -\log K_a$$

$$K_a =$$

$$K_a = \frac{[\text{H}^+]^2}{[\text{HA}]} = \frac{10^{-2.41}}{0.870}$$

$$10^{-2.41} = 3.89 \times 10^{-3}$$

$$\sqrt{10 \times 3.89 \times 10^{-3}} = 0.062$$

$$K_a = \frac{0.062}{0.870} = 0.072$$

$$-\log K_a = 1.14$$

$$\text{p}K_a = 1.14$$

(iii) Determine the percentage dissociation of ethanoic acid in the vinegar.

Give your answer to three significant figures.

$$10^{-\text{p}K_a} = K_a$$

$$10^{-1.14} = 0.072$$

$$10^{-2.41} = 3.89 \times 10^{-3}$$

$$\frac{7.2 \times 10^{-2}}{3.89 \times 10^{-3}} = 18.5\%$$

$$\text{percentage dissociation} = 18.5\%$$



(b) Many solid drain cleaners are based on sodium hydroxide, NaOH.

- A student dissolves 1.26 g of a drain cleaner in water and makes up the solution to 100.0 cm³.
- The student measures the pH of this solution as 13.48.

Determine the percentage, by mass, of NaOH in the drain cleaner.

Give your answer to three significant figures.

$$K_w = [H^+][OH^-] = [H^+]^2$$

$$10^{-13.48} = 3.31 \times 10^{-14}$$

$$K_w = 1.0 \times 10^{-14}$$

$$K_w [OH^-] = \frac{K_w}{[H^+]}$$

$$[OH^-] = \frac{1.0 \times 10^{-14}}{3.31 \times 10^{-14}} = 0.302$$

$$M_r \text{ of NaOH}$$

$$= 23.0 + 16 + 1 = 40$$

$$\frac{1.26 \text{ g}}{40}$$

$$0.0315 = 0.0315 \text{ moles}$$

$$\frac{0.0315}{0.1} = 0.315$$

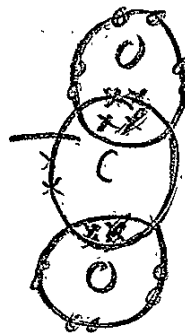
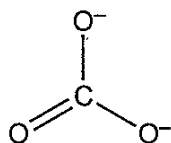
$$\frac{0.302}{0.315} \times 100$$

$$= 95.9$$

percentage = 95.9 % [4]

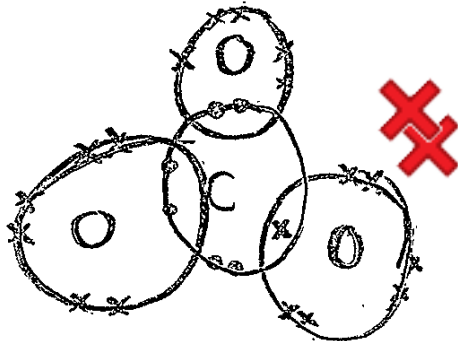
(c) Sodium carbonate, Na₂CO₃, is a base used in washing soda.

Na₂CO₃ contains the carbonate ion, CO₃²⁻, shown below.



Draw the 'dot-and-cross' diagram for the carbonate ion.

Show outer electrons only and use different symbols for electrons from C and O, and any 'extra' electrons.



[2]

Turn over



20 This question is about the halogen group of elements and some of their compounds.

- (a) The halogens show trends in their properties down the group.

The boiling points of three halogens are shown below.

Halogen	Boiling point/°C
Chlorine	-35
Bromine	59
Iodine	184

B.P ↓

Explain why the halogens show this trend in boiling points.

The trend is that going down ~~the~~ the halogen group, the boiling point decreases. This is because as the ~~atomic~~ atomic radius increases, the -1 charge is spread over a bigger ~~atom~~ atom. This means that there are weaker London forces in Iodine which is the bigger ~~not~~ element compared to Chlorine and Bromine. Therefore ~~chlorine~~ Iodine requires small amounts of energy to overcome.

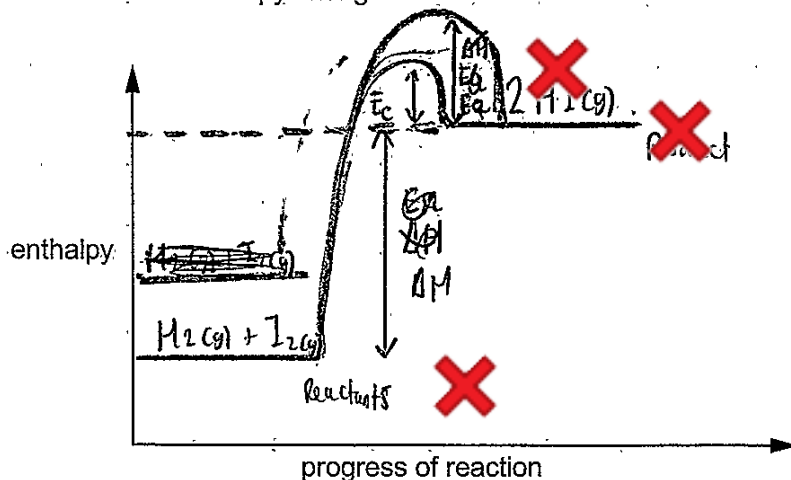
- (b) Hydrogen iodide, HI, is decomposed by heat into its elements:



The decomposition is much faster in the presence of a platinum catalyst.

Complete the enthalpy profile diagram for this reaction using formulae for the reactants and products.

- Use E_a to label the activation energy **without** a catalyst.
- Use E_c to label the activation energy **with** a catalyst.
- Use ΔH to label the enthalpy change of reaction.



[3]



- (c) Compound A is an oxide of chlorine that is a liquid at room temperature and pressure and has a boiling point of 83 °C.

When 0.4485 g of A is heated to 100 °C at 1.00×10^5 Pa, 76.0 cm³ of gas is produced.

Determine the molecular formula of compound A.

Show all your working.

$$pV = nRT$$

$$n = \frac{pV}{RT}$$

0.076

$$n = \frac{1 \times 10^5 \times 0.076 \text{ dm}^3}{8.314 \times 373} = \frac{2450.7 \text{ molar}}{2450.7} = 2.45 \text{ molar}$$

$$M_r = \frac{0.4485 \text{ g}}{2.45} = 1.83 \times 10^{-4} \times 0.183$$

5x-f

$$\times 24 \quad 2.45 \times 24 = 58.8$$

$$6.9 + 35.5 = 42.4$$

$$+ 16 = 58.4$$

$$2.45 \times 24$$

$$2.45 \times 24.3 + 35.5 = 76.000$$

$$2450725.9$$

$$2450725.9$$

molecular formula of A = LiClO [4]



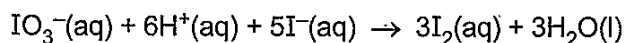
- (d) Compound **B** is an iodate(V) salt of a Group 1 metal.
The iodate(V) ion has the formula IO_3^- .

A student carries out a titration to find the formula of compound **B**.

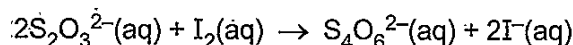
Step 1: The student dissolves 1.55 g of **B** in water and makes up the solution to 250.0 cm^3 in a volumetric flask.

Step 2: The student pipettes 25.00 cm^3 of the solution of **B** into a conical flask, followed by 10 cm^3 of dilute sulfuric acid and an excess of $\text{KI}(\text{aq})$.

The iodate(V) ions are reduced to iodine, as shown below.



Step 3: The resulting mixture is titrated with $0.150 \text{ mol dm}^{-3} \text{ Na}_2\text{S}_2\text{O}_3(\text{aq})$.



The student repeats **step 2** and **step 3** until concordant titres are obtained.

Titration readings

Titration	Trial	1	2	3
Final burette reading / cm^3	24.00	47.40	23.75	47.05
Initial burette reading / cm^3	0.00	24.00	0.00	23.20
Titre / cm^3	24.00	23.40	23.75	23.85

Table 20.1

- (i) Complete **Table 20.1** and calculate the mean titre that the student should use for analysing the results.

$$\frac{23.75 + 23.85}{2} = 23.8$$

mean titre = 23.8 cm^3 [2]

- (ii) The uncertainty in each burette reading is $\pm 0.05 \text{ cm}^3$.

Calculate the percentage uncertainty in the titre obtained from **titration 1**.

Give your answer to **two** decimal places.

$$\frac{0.05 \times 2}{23.40} \times 100 = 0.43$$

percentage uncertainty = 0.43 % [1]



- (iii) Describe and explain how the student should determine the end point of this titration accurately.

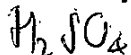
By taking a reading when the colour of Iodine changes.



[2]

- (iv) Determine the relative formula mass and formula of the Group 1 iodate(V), B.

Show your working:



$$n = 3$$

$$c = 3$$

$$v = 0.01$$



2



$$n = 3$$

$$c = 3$$

$$v = 0.02$$



relative formula mass of B =

formula of B = [5]



21 This question is about some reactions of d block elements and their ions.

Table 21.1 shows standard electrode potentials which will be needed within this question.

$\text{Zn}^{2+}(\text{aq}) + 2\text{e}^{-}$	\rightleftharpoons	$\text{Zn}(\text{s})$	$E^{\circ} = -0.76\text{V}$
$\text{Cr}^{3+}(\text{aq}) + \text{e}^{-}$	\rightleftharpoons	$\text{Cr}^{2+}(\text{aq})$	$E^{\circ} = -0.42\text{V}$
$\text{Ni}^{2+}(\text{aq}) + 2\text{e}^{-}$	\rightleftharpoons	$\text{Ni}(\text{s})$	$E^{\circ} = -0.25\text{V}$
$\text{I}_2(\text{aq}) + 2\text{e}^{-}$	\rightleftharpoons	$2\text{I}^{-}(\text{aq})$	$E^{\circ} = +0.54\text{V}$
$\text{Fe}^{3+}(\text{aq}) + \text{e}^{-}$	\rightleftharpoons	$\text{Fe}^{2+}(\text{aq})$	$E^{\circ} = +0.77\text{V}$
$\text{Cr}_2\text{O}_7^{2-}(\text{aq}) + 14\text{H}^{+}(\text{aq}) + 6\text{e}^{-}$	\rightleftharpoons	$2\text{Cr}^{3+}(\text{aq}) + 7\text{H}_2\text{O}(\text{l})$	$E^{\circ} = +1.33\text{V}$
$\text{H}_2\text{O}_2(\text{aq}) + 2\text{H}^{+}(\text{aq}) + 2\text{e}^{-}$	\rightleftharpoons	$2\text{H}_2\text{O}(\text{l})$	$E^{\circ} = +1.78\text{V}$

Arrow
reverse
oxidised

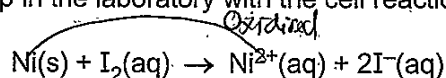
Table 21.1

(a) Complete the electron configuration of

a Ni atom: $1s^2$ $2s^2 2p^6 3s^2 3p^6 4s^2 3d^8$ 28

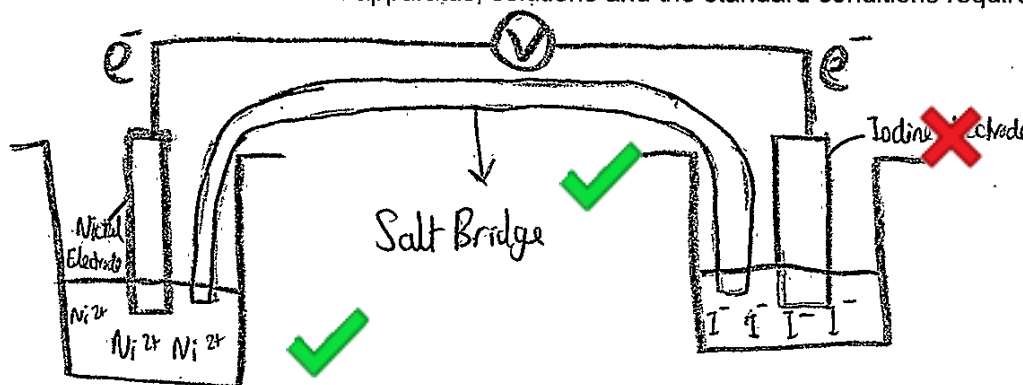
a Ni²⁺ ion: $1s^2$ $2s^2 2p^6 3s^2 3p^6 3d^8$ 26 [2]

(b) A standard cell is set up in the laboratory with the cell reaction shown below:



(i) Draw a labelled diagram to show how this cell could be set up to measure its standard cell potential.

Include details of apparatus, solutions and the standard conditions required.



Standard conditions: Concentrations are 1.00mol dm^{-3} , 298K
and 100kPa .

[4]



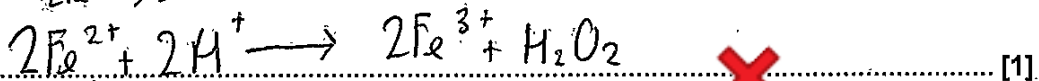
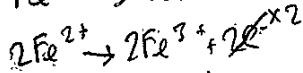
- (ii) Predict the standard cell potential of this cell.

$$+0.54\text{V} - -0.25\text{V}$$

$$\text{standard cell potential} = \dots\dots\dots +0.79 \quad \checkmark [1]$$

- (c) Use the information in Table 21.1 to help you answer both parts of this question.

- (i) Write the overall equation for the oxidation of
- Fe^{2+}
- by acidified
- H_2O_2
- .

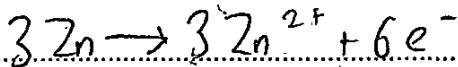
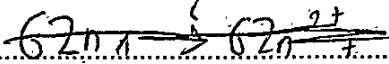
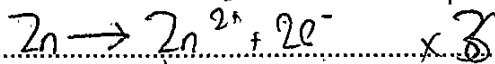
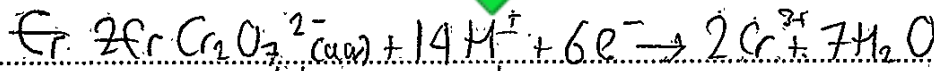


- (ii) Zinc reacts with acidified
- $\text{Cr}_2\text{O}_7^{2-}$
- ions to form
- Cr^{2+}
- ions in two stages.

Explain why this happens in terms of electrode potentials and equilibria.

Include overall equations for the reactions which occur.

As zinc the zinc half cell has a negative E^\ominus , it is easily oxidised. $\text{Zn} \rightarrow \text{Zn}^{2+} + 2e^-$. $\text{Cr}_2\text{O}_7^{2-}$ has a positive E^\ominus meaning it gains electrons. E cell of this equation = $+1.3\text{V} - -0.76\text{V} = +2.09\text{V}$ meaning reaction is feasible.



$\rightarrow =$

[4]



(d)* Three different reactions of copper compounds are described below.

Reaction 1: Aqueous copper(II) sulfate reacts with excess aqueous ammonia in a ligand substitution reaction. A deep-blue solution is formed, containing an octahedral complex ion, **C**, which is a *trans* isomer. $\text{Cu}(\text{H}_2\text{O})_6$ $\text{Cu}(\text{OH})_4$ $(\text{NH}_3)_2$

Reaction 2: Copper(I) oxide reacts with hot dilute sulfuric acid in a disproportionation reaction. A blue solution, **D**, and a brown solid, **E** are formed.

Reaction 3: Copper(II) oxide reacts with warm dilute nitric acid in a neutralisation reaction, to form a blue solution. Unreacted copper(II) oxide is filtered off, and the solution is left overnight in an evaporating basin.

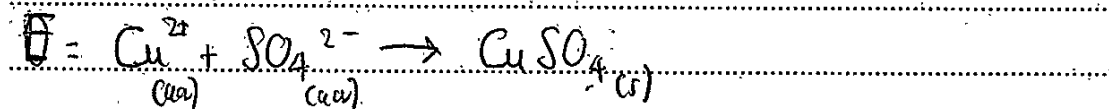
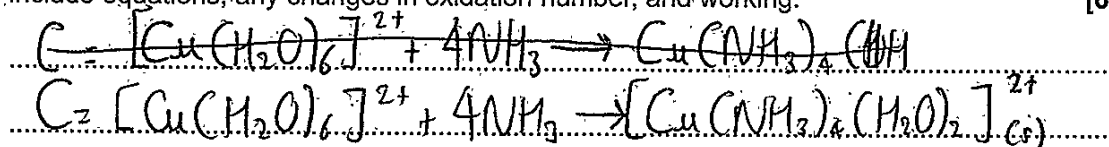
A hydrated salt, **F**, crystallises, with the percentage composition by mass:

Cu, 26.29%; H, 2.48%; N, 11.59%; O, 59.63%.

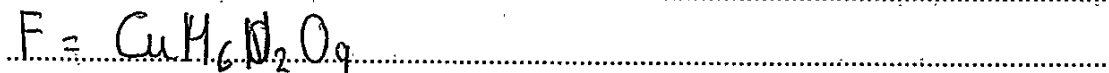
Identify **C–F** by formulae or structures, as appropriate.

Include equations, any changes in oxidation number, and working.

[6]



F	26.29%	2.48%	11.59%	59.63%
	$\frac{63.5}{63.5}$	$\frac{1}{1}$	$\frac{14}{14}$	$\frac{16}{16}$
	$\frac{-0.41}{0.41}$	$\frac{-2.48}{0.41}$	$\frac{-0.83}{0.41}$	$\frac{-3.73}{0.41}$
	$= 1$	$= 6$	$= 2$	$= 9$



A 11

Additional answer space if required.



SEEN

END OF QUESTION PAPER



ADDITIONAL ANSWER SPACE

If additional space is required, you should use the following lined page(s). The question number(s) must be clearly shown in the margin(s).

Lined area for writing answers, featuring a vertical margin line on the left and horizontal dotted lines for writing.

BP



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Off Page Comments

Item Name	Comment
21d	Incomplete attempt at 2 reactions for level 1. Communication is very poor. 1 mark awarded
20c	Unit conversions incorrect so MP1 not awarded, but ECF for MP2. No further credit given.
18b	1.2 on the answer line automatically gets 4 marks
17bi	Line drawn, gradient and E_a calculated, so first 2 MP can be awarded. Note: 3SF only required for MP3, but in this case MP3 not awarded due to lack of 10-3.
18cii	MP1 given for shift. MP2 not awarded. MP3 awarded for more NO_2 and keep K_p constant.
20b	Reactant and product labels reversed, delta H arrow is doubleheaded and EA/EC not from reactants line.
21cii	E cell value given so MP3 awarded and MP4 given as $\text{Cr}_2\text{O}_7^{2-}$ gains electrons. No equations. (Zn has a negative E is not sufficient as there is no comparison - but gets this mark for 2.09V anyway)
16ai	Gaseous ions dissolve in water is allowed for MP2
17a	Orders correctly determined with experimental evidence. Value of k incorrect and reactant side in first step of mechanism does not fit the rate equation. Has attempted rate equation. Level 1 answer 2 marks.
17bii	y intercept = 31.3 in guidance for 1st MP.
19aai	MP2 candidate has square rooted rather than squared concentration of H^+ but then gone on to calculate K_a . MP3 for p K_a awarded as ECF.
16aiv	No reference to size so 1st MP not awarded but links F^- to attraction to water molecules so 2nd MP given