Please write clearly in block capitals.

Centre number | | | | | | Candidate number | | | | |

Surname _____

Forename(s) _____

Candidate signature _____

A-level CHEMISTRY

Paper 3

Wednesday 20 June 2018 Morning Time allowed: 2 hours

Materials

For this paper you must have:
- the Periodic Table/Data Booklet, provided as an insert (enclosed)
- a ruler with millimetre measurements
- a scientific calculator, which you are expected to use where appropriate.

Instructions
- Use black ink or black ball-point pen.
- Fill in the boxes at the top of the page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do **not** write outside the box around each page or on blank pages.
- All working must be shown.
- Do all rough work in this book. Cross through any work you do not want to be marked.

Information
- The marks for questions are shown in brackets.
- The maximum mark for this paper is 90.

Advice
- You are advised to spend about 70 minutes on **Section A** and 50 minutes on **Section B**.

For Examiner's Use	
Question	Mark
1	
2	
3	
4	
Section B	
TOTAL	

Section A

Answer **all** questions in this section.

0 1 Iodide ions are oxidised to iodine by hydrogen peroxide in acidic conditions.

$$H_2O_2(aq) + 2H^+(aq) + 2I^-(aq) \rightarrow I_2(aq) + 2H_2O(l)$$

The rate equation for this reaction can be written as

$$rate = k[H_2O_2]^a[I^-]^b[H^+]^c$$

In an experiment to determine the order with respect to $H^+(aq)$, a reaction mixture is made containing $H^+(aq)$ with a concentration of 0.500 mol dm^{-3}

A large excess of both H_2O_2 and I^- is used in this reaction mixture so that the rate equation can be simplified to

$$rate = k_1[H^+]^c$$

0 1 . 1 Explain why the use of a large excess of H_2O_2 and I^- means that the rate of reaction at a fixed temperature depends only on the concentration of $H^+(aq)$.

[2 marks]

The concentration of H_2O_2 and I^- are effectively constant so they have no effect on the rate

0 1 . 2 Samples of the reaction mixture are removed at timed intervals and titrated with alkali to determine the concentration of $H^+(aq)$.

State and explain what must be done to each sample before it is titrated with alkali.

[2 marks]

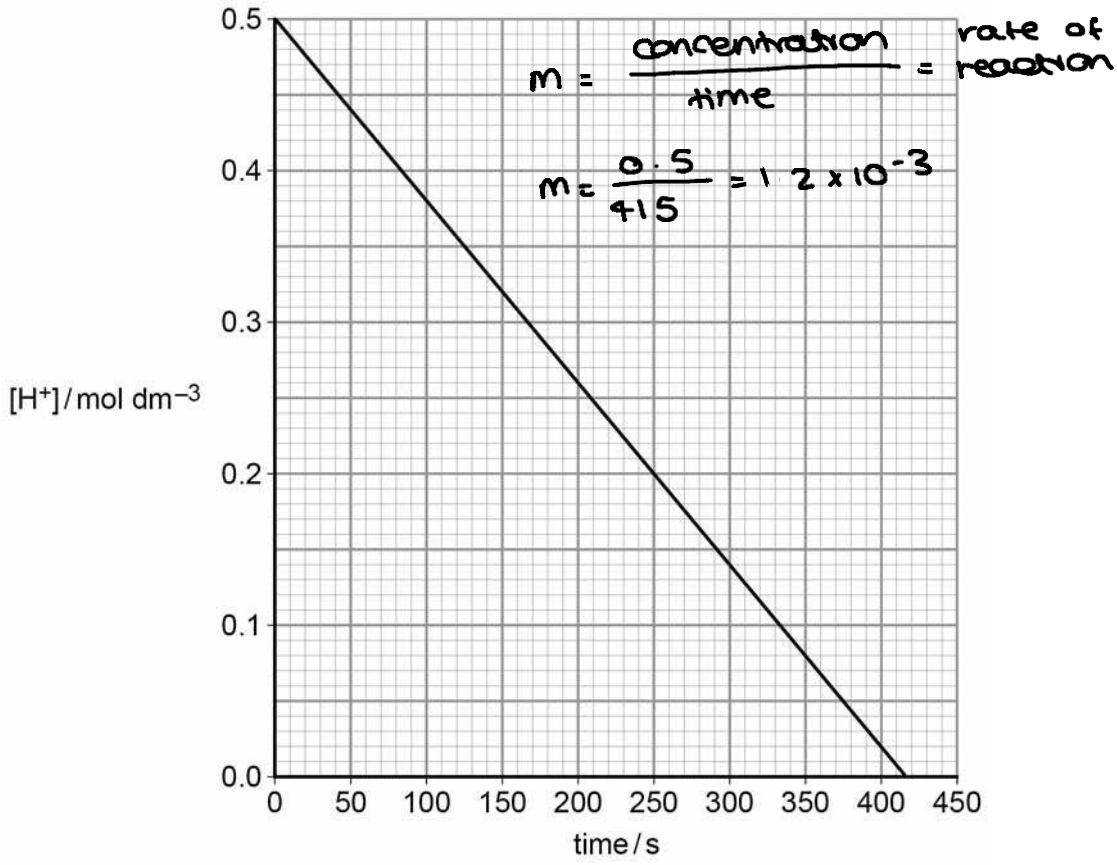
Stop the reaction by cooling the sample

- Dilute

- Add a reagent to remove H_2O_2 and I^-

0 1 . 3 A graph of the results is shown in **Figure 1.**

Figure 1



Explain how the graph shows that the order with respect to $H^+(aq)$ is zero.

[2 marks]

The gradient is constant so the rate of reaction is also constant as $[H^+]$ changes.

0 1 . 4 Use the graph in **Figure 1** to calculate the value of k_1
Give the units of k_1

[3 marks]

rate = $k_1[H^+]^c$

$c = 0$

rate = k_1

= $mol dm^{-3} s^{-1}$

k_1 1.2×10^{-3}

Units $mol dm^{-3} s^{-1}$

0 1 . 5 A second reaction mixture is made at the same temperature. The initial concentrations of $H^+(aq)$ and $I^-(aq)$ in this mixture are both 0.500 mol dm^{-3} There is a large excess of H_2O_2

In this reaction mixture, the rate depends only on the concentration of $I^-(aq)$.

The results are shown in **Table 1.**

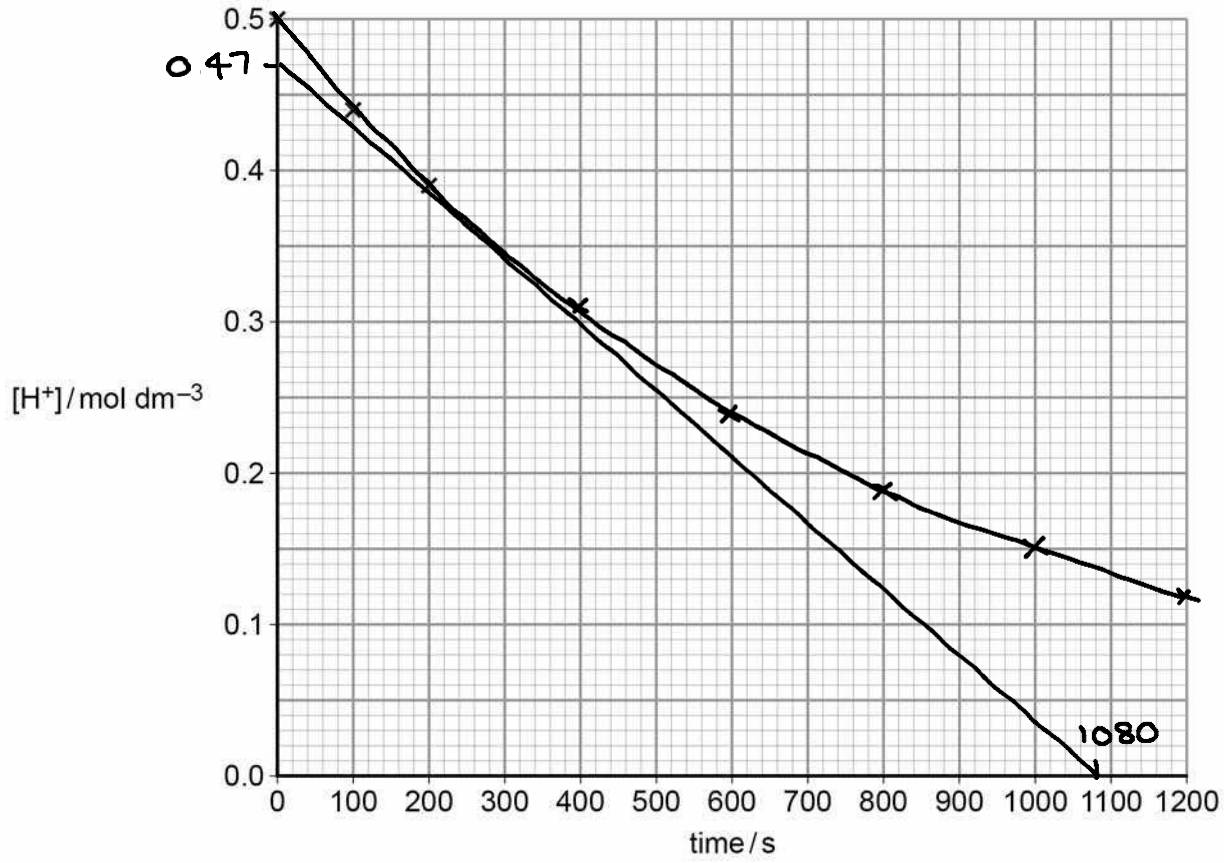
Table 1

Time / s	0	100	200	400	600	800	1000	1200
$[H^+]$ / mol dm^{-3}	0.50	0.44	0.39	0.31	0.24	0.19	0.15	0.12

Plot these results on the grid in **Figure 2.** The first three points have been plotted.

[1 mark]

Figure 2



0 1 . 6 Draw a line of best fit on the grid in **Figure 2.**

[1 mark]

0 1 . 7 Calculate the rate of reaction when $[H^+] = 0.35$ mol dm^{-3}
Show your working using a suitable construction on the graph in **Figure 2.**

[2 marks]

$$\text{rate} = \frac{\Delta y}{\Delta x} = \frac{0.47}{1080} = 4.35 \times 10^{-4} \text{ mol dm}^{-3} \text{ s}^{-1}$$

Rate 4.35×10^{-4} mol dm^{-3} s^{-1}

Question 1 continues on the next page

0 1 . 8 A general equation for a reaction is shown.

$$\mathbf{A}(aq) + \mathbf{B}(aq) + \mathbf{C}(aq) \rightarrow \mathbf{D}(aq) + \mathbf{E}(aq)$$

In aqueous solution, **A**, **B**, **C** and **D** are all colourless but **E** is dark blue.

A reagent (**X**) is available that reacts rapidly with **E**. This means that, if a small amount of **X** is included in the initial reaction mixture, it will react with any **E** produced until all of the **X** has been used up.

Explain, giving brief experimental details, how you could use a series of experiments to determine the order of this reaction with respect to **A**. In each experiment you should obtain a measure of the initial rate of reaction.

preparation, Procedure, Analysis **[6 marks]**

Measure known volumes of A, B, C and X into separate containers. Mix the four species together and start a timer. Record how long it takes for a blue colour to appear. Repeat the procedure with different concentrations of A but all other concentrations must be constant. All volumes, including A's must be constant. The temperature must be constant. Calculate $^1/_t$ as a measure of initial rate. Plot $\log_{10}(^1/_t)$ against $\log_{10}([A])$. Calculate the gradient - this will be the order with respect to A.

19

0 2 The elements sodium to sulfur in Period 3 all react with oxygen to form oxides.

0 2 . 1 Give an equation and **two** observations made for the reaction that occurs when sodium is heated in oxygen.

[2 marks]

Equation $4Na + O_2 \longrightarrow 2Na_2O$

Observation 1 Yellow - orange flame

Observation 2 Formation of a white powder

0 2 . 2 Give an equation and **one** observation made for the reaction that occurs when phosphorus is heated in oxygen.

[2 marks]

Equation $4P + 5O_2 \longrightarrow P_4O_{10}$

Observation White flame

0 2 . 3 The melting points of the highest oxides of the elements sodium to sulfur are shown in **Table 2**.

Table 2

	Highest oxide of					
	sodium	magnesium	aluminium	silicon	phosphorus	sulfur
Melting point/K	1548	3125	2345	1883	573	290

Explain the increase in melting point from sodium oxide to magnesium oxide.

[2 marks]

The magnesium ion has a greater charge than the sodium ion, so has a stronger attraction to the oxygen anions

0 2 . 4 Explain why the melting point of the oxide of silicon is much higher than that of the highest oxide of phosphorus.

[3 marks]

Silicon oxide has a macromolecular structure, whereas Phosphorus oxide is simple molecular. The bonds in silicon oxide's structure are stronger than the intermolecular forces between molecules of phosphorus oxide.

0 2 . 5 A sample of the highest oxide of phosphorus was prepared in a laboratory.

Describe a method for determining the melting point of the sample.
State how the result obtained could be used to evaluate its purity.

[3 marks]

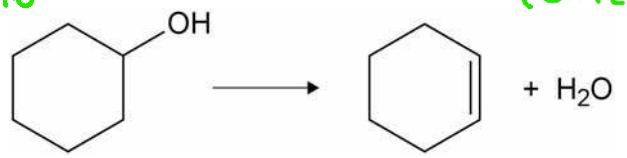
Place the sample into a suitable melting point apparatus, such as a Thiele tube. Heat the sample gradually. A broad melting range indicates impurities.

12

0 3 Cyclohexene (boiling point = 83 °C) can be prepared by the dehydration of cyclohexanol (boiling point = 161 °C) using concentrated phosphoric acid.

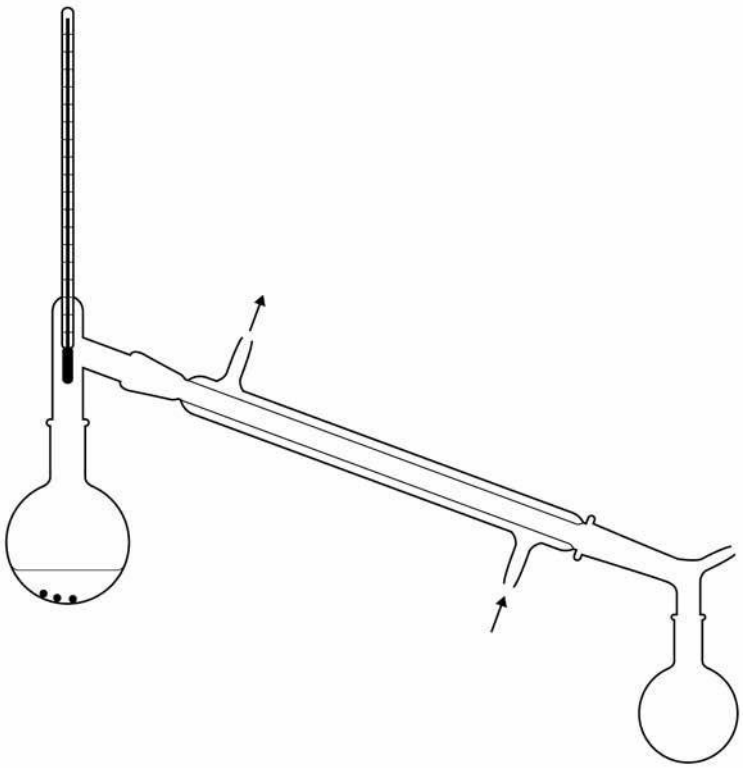
(6×12) + 12 + 16 = 100 g mol⁻¹

(6×12) + 10 = 82 g mol⁻¹



A student prepared cyclohexene by placing 10 cm^3 of cyclohexanol (density = 0.96 g cm^{-3}) into a round-bottomed flask.
3 cm^3 of concentrated phosphoric acid were then carefully added to the flask.
The student added a few anti-bumping granules and set up the apparatus shown in **Figure 3**.

Figure 3

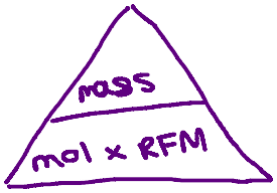


- The student heated the mixture and collected the liquid that distilled at temperatures below 100 °C
- The distillate was poured into a separating funnel and washed by shaking with sodium carbonate solution.
- Periodically, the separating funnel was inverted and the tap opened.
- The aqueous layer was discarded and the final organic product was dried using anhydrous calcium chloride.
- After the product was dried, the drying agent was removed by filtration under reduced pressure.

0 3 . 1 The student collected 5.97 g of cyclohexene in the experiment.

Calculate the percentage yield of cyclohexene.

[3 marks]



$10 \times 0.96 = 9.6$ g

$\frac{9.6}{100} = 0.096$ mol of cyclohexanol

$0.096 \times 82 = 7.87$ g max mass of cyclohexene

$\frac{5.97}{7.87} \times 100 = 76\%$

$\frac{5.97}{82} = 0.0728$ mol cyclohexene

$\frac{0.0728}{0.096} \times 100 = 76\%$

Percentage yield 76 %

0 3 . 2 Describe a test-tube reaction, on the product, to show that the cyclohexanol had been dehydrated. → cyclohexene

State what you would observe.

↳ test for alkene

[2 marks]

Add bromine water would turn from orange to colourless / decolourise

0 3 . 3 Suggest why sodium carbonate solution was used to wash the distillate.

↳ used to test for acid

[1 mark]

Carbonate + acid → CO_2 + salt + water

Na_2CO_3 would neutralise / react with / remove phosphoric acid / H_3PO_4 / H^+

0 3 . 4 Explain why it is important to open the tap of the separating funnel periodically.

[1 mark]

avoid pressure build up / release pressure / release CO_2 / air / gas / prevent stopper blowing out

Question 3 continues on the next page

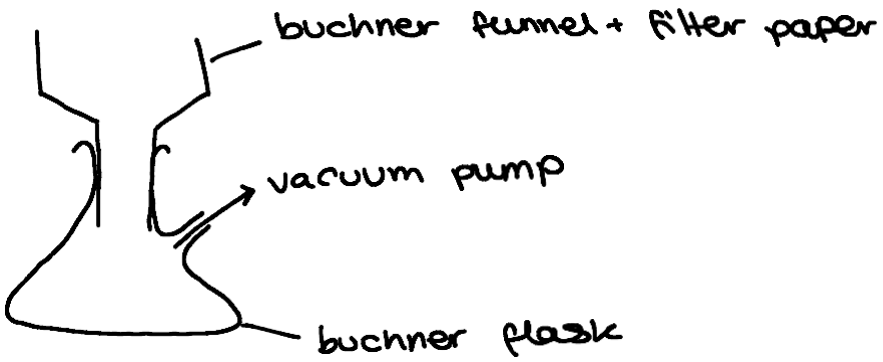
0 3 . 5 Give a property of anhydrous calcium chloride, other than its ability to absorb water, that makes it suitable as a drying agent in this preparation.

[1 mark]

Doesn't dissolve in / react with cyclohexene

0 3 . 6 Describe the apparatus used to remove the drying agent by filtration under reduced pressure. Your description of the apparatus can be either a labelled diagram **or** a description in words.

[2 marks]



0 3 . 7 A sample of cyclohexene has been contaminated with cyclohexanol. The cyclohexene can be separated from the cyclohexanol by column chromatography. Silica gel is used as the stationary phase and hexane as the mobile phase.

Explain why cyclohexene has a shorter retention time than cyclohexanol.

[2 marks]

Cyclohexene is less polar than cyclohexanol

Cyclohexene has a greater affinity for the mobile phase / hexane

Cyclohexanol has a greater affinity for the stationary phase / silica

0 3 . 8 Explain how an infrared spectrum would confirm that the cyclohexene obtained from the chromatography column did **not** contain any cyclohexanol.

[1 mark]

would be no peak at 3230 - 3550 cm^{-1} due to O-H / no additional peaks in the fingerprint region compared to a pure sample / fingerprint region exactly matches cyclohexene

13

Turn over for the next question

0 4 . 6 In a similar experiment to that in Question **04.5**, the enthalpy of neutralisation for the reaction between sulfuric acid and potassium hydroxide solution was found to be –57.0 kJ mol^{-1} per mole of water formed.

H_2SO_4 is a strong acid

more exothermic

Suggest an explanation for the difference between this value and your answer to Question **04.5**.
(If you were unable to obtain an answer to Question **04.5** you should assume a value of –28.5 kJ mol^{-1}. This is **not** the correct answer.)

[2 marks]

HOOCCOOH is a weak acid / not fully dissociated more energy is needed to break bonds / complete dissociation / dissociation is endothermic

16

Turn over for Section B

0 4 A student carried out an experiment to find the temperature rise for a reaction between hydrochloric acid and sodium hydroxide solution.

- The student used a measuring cylinder to place 50 cm^3 of 0.400 mol dm^{-3} hydrochloric acid into a glass beaker.
- The student recorded the temperature at one-minute intervals for three minutes.
- At the fourth minute the student added 50 cm^3 of 0.400 mol dm^{-3} sodium hydroxide solution and stirred to mix the solutions, but did not record the temperature.
- The student recorded the temperature at one-minute intervals for a further eight minutes.

The results are shown in **Table 3.**

Table 3

Time/min	0	1	2	3	4	5	6	7	8	9	10	11	12
Temperature / °C	19.8	19.8	19.8	19.8		21.4	21.7	21.6	21.5	21.4	21.3	21.2	21.1

0 4 . 1 Plot a graph of temperature against time on the grid opposite.
Use your graph to find the temperature rise, ΔT, at the fourth minute.
Show your working on the graph by drawing suitable lines of best fit.

[5 marks]

21.9 - 19.8 = 2.1 °C

ΔT 2.1 °C

0 4 . 2 The uncertainty in each of the temperature readings from the thermometer used in this experiment was ±0.1° C

Calculate the percentage uncertainty in the value for the temperature rise.

[1 mark]

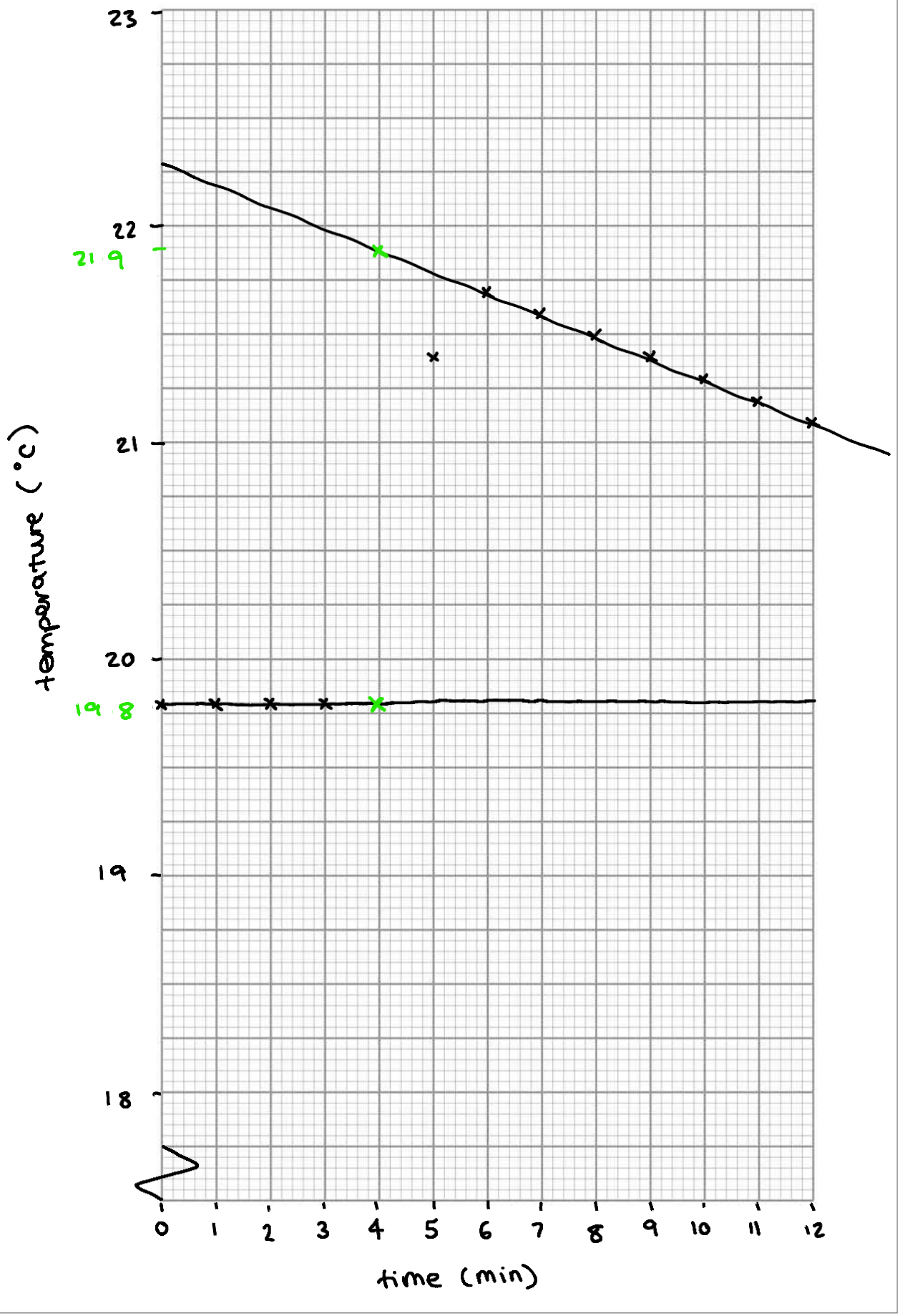
$\frac{0.1 \times 2}{2.1} \times 100 = 9.5\%$ → used a thermometer twice to calculate temperature rise

Percentage uncertainty 9.5 %

0 4 . 3 Suggest a change to the experiment that would minimise heat loss.

[1 mark]

replace the glass beaker with a polystyrene cup / insulate the glass beaker / use a lid



0 4 . 4 Suggest and explain another change to the experiment that would decrease the percentage uncertainty in the use of the same thermometer.

[2 marks]

need to increase denominator to reduce % uncertainty

increase magnitude of temperature change by increasing the concentration of the acid/ alkali

$$\frac{\text{instrument uncertainty}}{\text{temperature rise}} \times 100$$

0 4 . 5 A second student completed an experiment to determine the enthalpy of neutralisation for the reaction between ethanedioic acid solution (HOOCCOOH) and potassium hydroxide solution.

The student added 25 cm^3 of 0.80 mol dm^{-3} ethanedioic acid solution to 75 cm^3 of 0.60 mol dm^{-3} potassium hydroxide solution.
The temperature increased by 3.2 °C

Give an equation for the reaction between ethanedioic acid solution and potassium hydroxide solution.
Calculate the enthalpy change (ΔH) per mole of water formed in this reaction.
Assume that the specific heat capacity of the reaction mixture is 4.2 $J K^{-1} g^{-1}$
Assume that the density of the reaction mixture is 1.00 g cm^{-3}

[5 marks]

Equation $HOOCCOOH + 2KOH \longrightarrow K_2(OOCCOO) + 2H_2O$

$q = m \times c \times \Delta T$

$m = 75 + 25 = 100\ cm^3 = 100\ g$

$q = 100 \times 4.2 \times 3.2 = 1344\ J = 1.344\ kJ$

$25 \times 10^{-3} \times 0.8 = 0.02$ mol HOOCCOOH

$75 \times 10^{-3} \times 0.6 = 0.045$ mol KOH ← in excess

1:2 ratio of HOOCCOOH : H_2O

$0.02 \times 2 = 0.04$ mol H_2O

$\frac{1.344}{0.04} = 33.6\ kJ mol^{-1}$

exothermic reaction so negative ΔH

ΔH −33.6 kJ mol^{-1}

Section B

Answer **all** questions in this section.

Only **one** answer per question is allowed.
For each answer completely fill in the circle alongside the appropriate answer.

CORRECT METHOD ● WRONG METHODS ⊗ ◉ ≈ ∅

If you want to change your answer you must cross out your original answer as shown. ⊠

If you wish to return to an answer previously crossed out, ring the answer you now wish to select as shown. ◎

You may do your working in the blank space around each question but this will not be marked. Do **not** use additional sheets for this working.

Simplest way to write molecular formula

0 5 Which can be both an empirical and molecular formula of a stable compound?

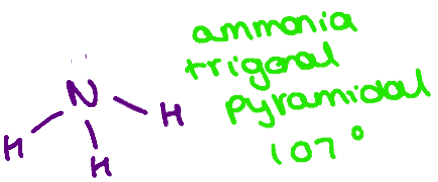
[1 mark]

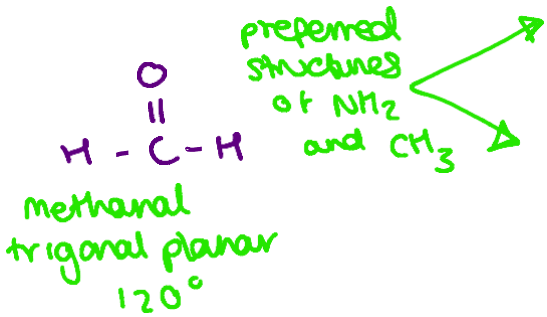
A CH_2O stable (methanal) ●

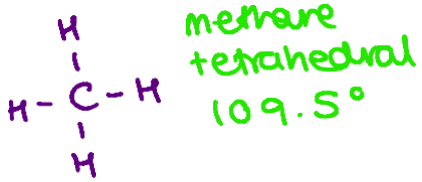
B P_4O_{10} P_2O_5 ⊖

C NH_2 not stable ⊖

D CH_3 not stable ⊖







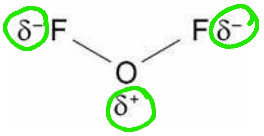
0 6 Which diagram shows the correct bonding and correct bond polarity in a molecule of oxygen difluoride?

oxygen forms 2 covalent bonds with Fluorine

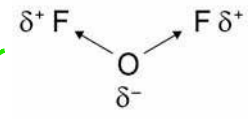
oxygen is more electropositive and Fluorine is more electronegative

[1 mark]

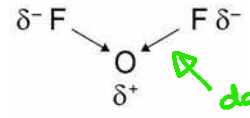
A



B

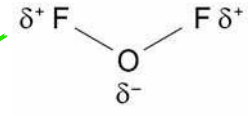


C



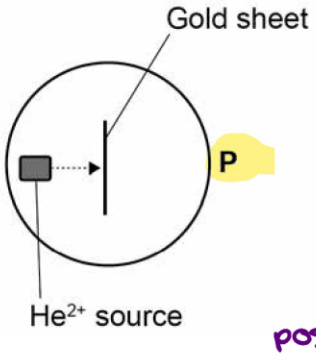
dative covalent bonds

D



Turn over for the next question

In the early twentieth century the apparatus shown in the diagram was used to investigate atomic structure. When He^{2+} particles were fired at a thin sheet of gold, most of the particles were detected at point **P**.



He^{2+} pass straight through because they haven't come into contact with the atom's positive nucleus and been deflected

0 7 What conclusion can be drawn from the detection of He^{2+} particles at point **P**?

[1 mark]

A Gold atoms contain electrons. ○

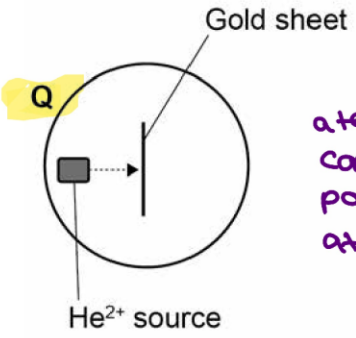
B Gold atoms contain protons. ○

C Gold atoms contain neutrons. ○

D Gold atoms are mainly empty space. ●

When He^{2+} particles were fired at a thin sheet of gold, about 1 in 8000 of the particles were detected at point **Q**.

small nucleus



atom's are deflected when they come into contact with the positive nucleus of a gold atom.

0 8 What conclusion can be drawn from the detection of He^{2+} particles at point **Q**?

[1 mark]

A Gold atoms have a small, positive nucleus. ●

B Gold atoms have electrons in orbitals. ○

C Gold consists of ions in a sea of delocalised electrons. ○

D Gold atoms have more protons than He^{2+} particles. ○

0 9 Which equation represents a termination step? two radicals react to form a non-radical (final step in free radical substitution) **[1 mark]**

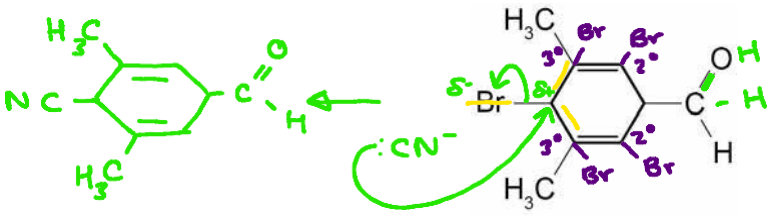
A $CH_3CH_2CH_3 + Br\bullet \rightarrow CH_3\dot{C}HCH_3 + HBr$ ○

B $ClO\bullet + O_3 \rightarrow Cl\bullet + 2O_2$ ○

C $RO\bullet + CH_2=CH_2 \rightarrow ROCH_2\dot{C}H_2$ ○

D $CH_3\dot{C}FCl + Cl\bullet \rightarrow CH_3CFCl_2$ ●

1 0 Which statement is correct about the molecule shown?



[1 mark]

A It reacts with HBr in an electrophilic ~~substitution~~ addition reaction. C=C → C-C ○

B It reacts with $NaBH_4$ in a nucleophilic addition ~~elimination~~ reaction. ○

C It reacts with ethanolic KOH in an elimination reaction. ↳ can't happen as C would have 5 bonds ○

D It reacts with KCN in a nucleophilic substitution reaction. ●

1 1 Which statement is correct about both 2-methylbutan-1-ol and 2-methylbutan-2-ol? **[1 mark]**

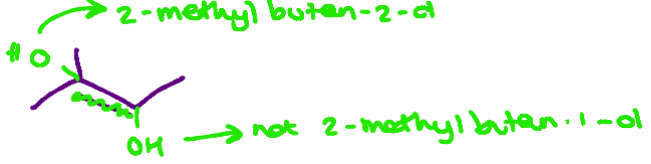
ester —alkali→ salt of carboxylic acid + alcohol — both alcohols and doesn't specify the ester so it's correct

A They can be formed by alkaline hydrolysis of esters. ●

B They can be oxidised by reaction with acidified potassium dichromate(VI). 3° alcohols can't be oxidised ○

C They can be formed by hydration of 2-methylbut-2-ene. ○

D They have four peaks in their ^{13}C NMR spectra. ○



1 2 Solutions of two compounds, **W** and **X**, react together in the presence of a soluble catalyst, **Y**, as shown in the equation

$$2\mathbf{W} + \mathbf{X} \rightarrow \mathbf{Z}$$

When the concentrations of **W**, **X** and **Y** are all doubled, the rate of reaction increases by a factor of four.

need an overall 2nd order rate equation with [W], [X] or [Z]

Which is a possible rate equation for this reaction?

overall rate equation

[1 mark]

A *rate* = k [**W**]^2 [**X**] 3rd

B *rate* = k [**W**]^2 [**Y**] 3rd

C *rate* = k [**X**] [**Y**] 2nd ●

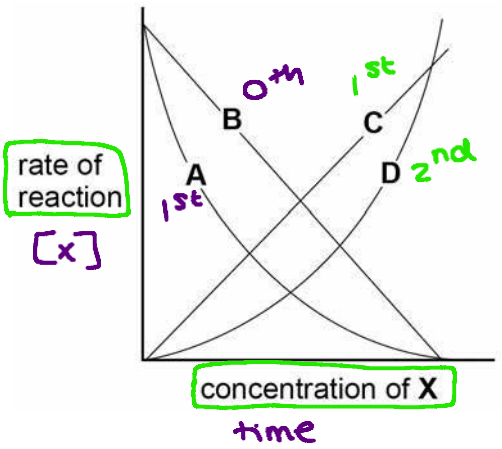
D *rate* = k [**X**] [**Z**] 2nd

only changing the concentration of W, X and Y not Z so would need a [W] or [Y] for this rate equation to work

1 3 A series of experiments was carried out to find the order of reaction with respect to reactant **X**. In these experiments, only the concentration of **X** was changed.

Which graph would show that the reaction is second-order with respect to **X**?

[1 mark]



A ○

B ○

C ○

D ●

1 4 Which equation represents the process that occurs when the standard enthalpy of atomisation of iodine is measured?

[1 mark]

ensures 1 mol

one mole of a sample (iodine) is dissociated into its atoms under standard conditions

A $\frac{1}{2} I_2(s) \rightarrow I(g)$ ●

B $I_2(s) \rightarrow 2I(g)$ ○

C $\frac{1}{2} I_2(g) \rightarrow I(g)$ ○

D $I_2(g) \rightarrow 2I(g)$ ○

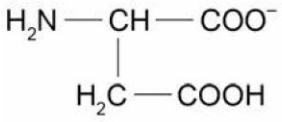
(s) → (g) = dissociation

1 5 Which structure is formed by aspartic acid in solution at pH 12?

[1 mark]

alkaline

A



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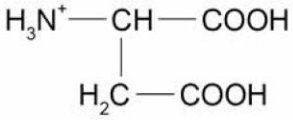

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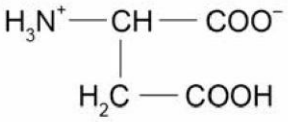

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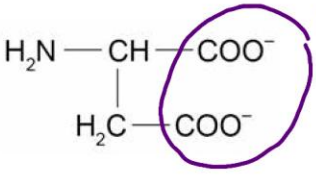
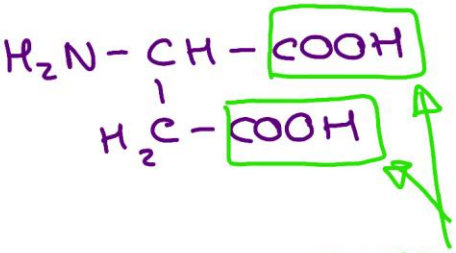




reacts with acidic parts of aspartic acid

both COOH groups have reacted with alkali to produce carboxylate ions

Turn over for the next question

Questions 16-18 are at the end of the document

1 9 Which products are formed when magnesium reacts with steam?

[1 mark]

products if Mg reacted with water

$H_2O_{(g)}$

$H_2O_{(l)}$

A Magnesium hydroxide and hydrogen ⬭

B Magnesium hydroxide and oxygen ⬭

products when Mg reacts with steam

C Magnesium oxide and hydrogen ●

D Magnesium oxide and oxygen ⬭

2 0 Which observation would confirm that ammonia gas is released when solid ammonium chloride is warmed with solid calcium hydroxide?

need to hold above mixture

[1 mark]

A Damp blue litmus paper turns red when touched onto the solid mixture. ⬭

B Damp red litmus paper turns blue when touched onto the solid mixture. ⬭

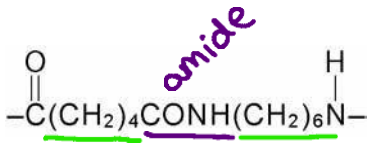
test for Cl_2 gas blue → red → white litmus paper colour change

C Damp blue litmus paper turns red when held just above the solid mixture. ⬭

D Damp red litmus paper turns blue when held just above the solid mixture. ●

Turn over for the next question

2 1 The repeating unit of a polymer is shown.



Which monomer or pair of monomers could be used to make this polymer?

[1 mark]

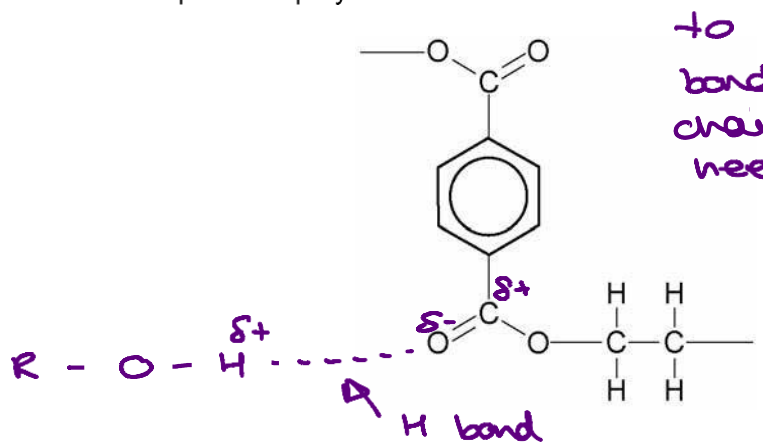
A $ClOC(CH_2)_4NH_2$ only won't alternate alkyl groups ○

B $ClOC(CH_2)_4COCl$ only can't form amides ○

C $ClOC(CH_2)_4COCl$ and $H_2N(CH_2)_6NH_2$ ●

D $ClOC(CH_2)_6COCl$ and $H_2N(CH_2)_4NH_2$ wrong alternation of alkyl groups ○

2 2 The structure of part of a polyester chain is shown.



Which statement correctly explains why plastics made from this polyester only soften at high temperatures?

[1 mark]

A Hydrogen bonds and van der Waals' forces exist between polyester chains. ○

B Permanent dipole-dipole forces and van der Waals' forces exist between polyester chains. ●

C The carbon-carbon bonds in the chain are strong. ○
↳ get in the way + reduce mp./bp.

D The carbon-oxygen bonds in the chain are strong. ○
↳ hydrolysis

easily broken

electrophilic substitution

2 3 The nitration of benzene uses a nitrating mixture of concentrated nitric acid and concentrated sulfuric acid.

$$HNO_3 + 2H_2SO_4 \rightarrow NO_2^+ + H_3O^+ + 2HSO_4^-$$

Which statement is correct?

[1 mark]

proton acceptor

A HNO_3 acts as a base. ●

H_2SO_4 = reformed at end of mechanism

B ~~HNO_3~~ acts as a catalyst. ○

NO_2^+

C ~~HNO_3~~ acts as an electrophile. ○

D HNO_3 acts as a ~~reducing agent.~~ reducing agent is oxidised but N is not ○

HNO_3: H (+1), N (+5), O (−2 × 3) = −6

NO_2^+: N (+5), O (−2 × 2) = −4

2 4 Aqueous solutions of ammonia, ethylamine and phenylamine are prepared. Each solution has the same concentration.

Which is the correct order for the pH values of these solutions?

[1 mark]

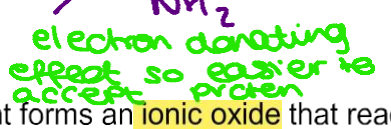
basic = proton acceptor ← acidic

A ammonia > ethylamine > phenylamine ○

B ammonia > phenylamine > ethylamine ○

C ethylamine > ammonia > phenylamine ●

D ethylamine > phenylamine > ammonia ○



lone pair on N is delocalised into the π ring system so harder to accept proton

2 5 Which element forms an ionic oxide that reacts with strong alkalis?

[1 mark]

needs an acid = neutralisation reaction

A Aluminium Al_2O_3 ●

B Magnesium MgO ○

C Sodium Na_2O ○

D Sulfur SO_2 ○

acid ↑ alkali

SO_2 ← covalent

2 9 Which ion **cannot** catalyse the reaction between iodide (I^-) and peroxodisulfate ($S_2O_8^{2-}$)?

Use the data below to help you answer this question.

[1 mark]

Half-equation	$E^{\ominus}$/V
$S_2O_8^{2-} + 2e^- \rightarrow 2SO_4^{2-}$	+2.01
$Co^{3+} + e^- \rightarrow Co^{2+}$	+1.82
$Fe^{3+} + e^- \rightarrow Fe^{2+}$	+0.77
$I_2 + 2e^- \rightarrow 2I^-$	+0.54
$Cr^{3+} + e^- \rightarrow Cr^{2+}$	–0.41

$S_2O_8^{2-} + 2Co^{2+} \rightarrow 2SO_4^{2-} + 2Co^{3+}$

$2Co^{3+} + 2I^- \rightarrow I_2 + 2Co^{2+}$

$S_2O_8^{2-} + 2Cr^{2+} \rightarrow 2SO_4^{2-} + 2Cr^{3+}$

$I_2 + 2Cr^{2+} \rightarrow 2I^- + 2Cr^{3+}$

$S_2O_8^{2-} + 2Fe^{2+} \rightarrow 2SO_4^{2-} + 2Fe^{3+}$

$2Fe^{3+} + 2I^- \rightarrow I_2 + 2Fe^{2+}$

A Co^{2+} ✓ ○

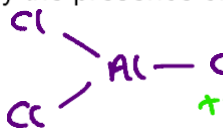
B Cr^{2+} ✗ ●

C Fe^{2+} ✓ ○

D Fe^{3+} ✓ ○

3 0 Which species has a shape that is influenced by the presence of one or more lone pairs of electrons around the central atom?

[1 mark]

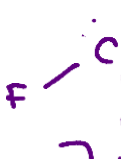


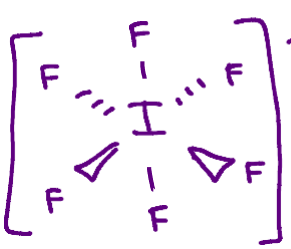
A $AlCl_3$ ○

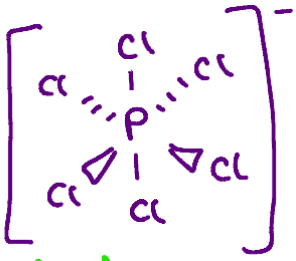
B ClF_3 ●

C IF_6^+ ○

D PCl_6^- ○







octahedral

Turn over for the next question

3 1 Some 1.0 mol dm^{-3} solutions were mixed using equal volumes of each solution.

Which pair of solutions would give the greatest mass of solid?

→ $BaSO_4$ insoluble solid

[1 mark]

A $Ba(OH)_2$ and $MgCl_2$ ○

B $Ba(OH)_2$ and $MgSO_4$ → $BaSO_4$ + $Mg(OH)_2$ ½ ½ ●

C $Ba(OH)_2$ and NaCl ○

D $Ba(OH)_2$ and Na_2SO_4 → $BaSO_4$ + $2NaOH$ ⅓ ⅔ ○

3 2 Which indicator should be used in a titration to find the concentration of a solution of methylamine using 0.010 mol dm^{-3} hydrochloric acid?

weak base — strong acid

[1 mark]

A Thymol blue (pH range 1.2–2.8) ○

B Bromophenol blue (pH range 3.0–4.6) ●

C Phenol red (pH range 6.8–8.4) ~~○~~

D Phenolphthalein (pH range 8.3–10.0) ~~○~~

Equivalence point = acidic region

3 3 Lattice enthalpy values can be obtained from Born–Haber cycles and by calculations based on a perfect ionic model.

Which compound shows the greatest percentage difference between these two values?

[1 mark]

A CsF ○

B CsI ●

C LiF ~~○~~

D LiI ●

Cs larger than Li so less covalent character so less covalent character

F has a smaller electron cloud so Li draws less electron density from F^-

large covalent character Li^+ small ion and I^- large ion Li^+ would draw electron density from I^- rather than pure ionic

3 4 For this reaction at equilibrium, which combination of temperature and pressure would give the greatest equilibrium yield of products?

$$W(g) + X(g) \rightleftharpoons 2Y(g) + Z(g) \qquad \Delta H = +47 \text{ kJ mol}^{-1}$$

2 (g) 3 (g)

endothermic forwards reaction

[1 mark]

A High pressure and high temperature ○

B High pressure and low temperature ○

C Low pressure and high temperature ●

D Low pressure and low temperature ○

decreasing pressure shifts equilibrium position to favour side with more moles

increasing temperature shifts equilibrium position to endothermic direction

30

END OF QUESTIONS

2 6 Which statement is correct about this reaction?

$$[Co(NH_3)_6]^{2+} + 3H_2NCH_2CH_2NH_2 \rightarrow [Co(H_2NCH_2CH_2NH_2)_3]^{2+} + 6NH_3$$

[1 mark]

A The co-ordination number of cobalt decreases.

B The enthalpy change is large and positive.

C The entropy change is large and positive.

D The shape of the complex changes from octahedral.

2 7 Which complex exists as optical isomers?

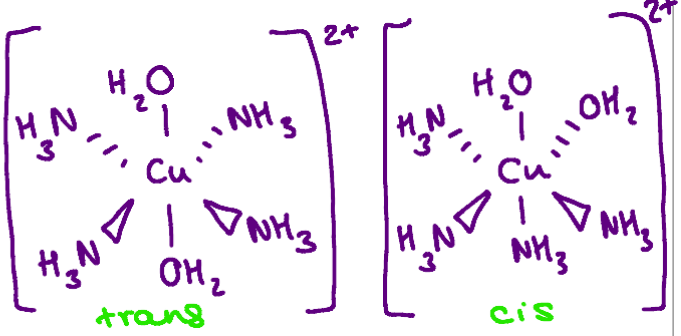
[1 mark]

A $[Ag(NH_3)_2]^+$

B $[Co(C_2O_4)_3]^{4-}$

C $[Cu(EDTA)]^{2-}$

D $[Cu(NH_3)_4(H_2O)_2]^{2+}$



2 8 How many structural isomers with the molecular formula $C_5H_{10}O$ react with Tollens' reagent?

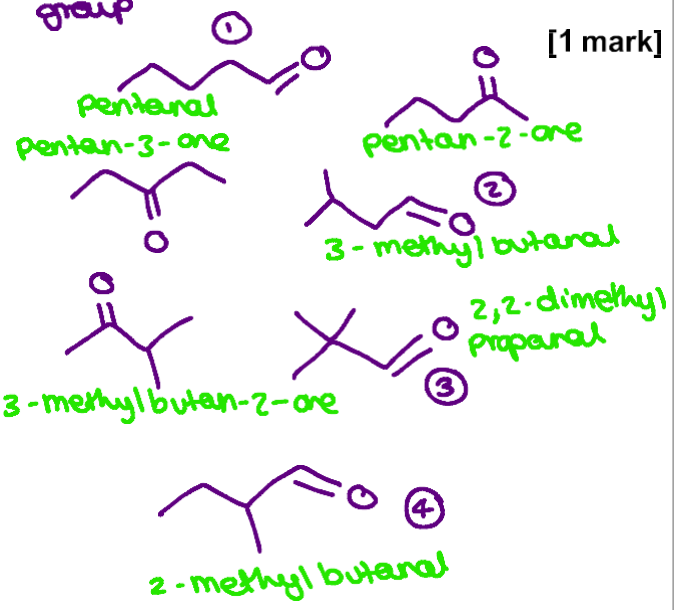
[1 mark]

A 3

B 4

C 5

D 6



1 6 How many peaks are there in the ^{13}C NMR spectrum of 1,4-dimethylbenzene?

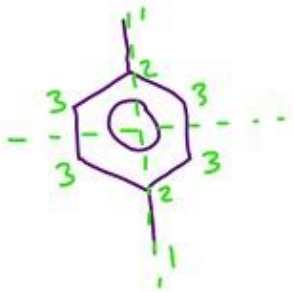
[1 mark]

A 8 ○

B 4 ○

C 3 ●

D 2 ○



1 7 Which of these Period 3 elements has the highest melting point?

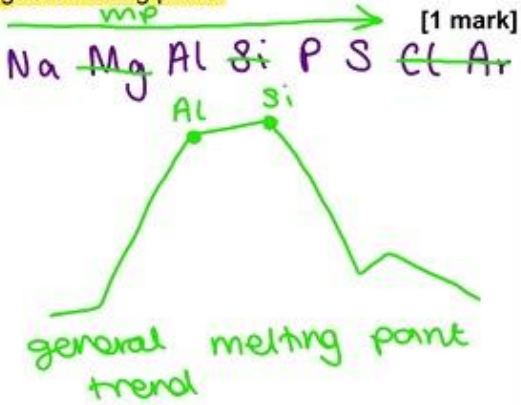
[1 mark]

A Aluminium ●

B Phosphorus ○

C Sodium ○

D Sulfur ○



1 8 Chlorine reacts with cold, dilute, aqueous sodium hydroxide.

Which is a complete list of the products?

$Cl_2 + 2NaOH \longrightarrow NaCl + H_2O +$

[1 mark]

A Sodium chloride, sodium chlorate(I) and water ●

B Sodium chlorate(I) and water ○

C Sodium chloride, sodium chlorate(V) and water ○

D Sodium chloride and sodium chlorate(I) ○