OXFORD

INTERNATIONAL
AQA EXAMINATIONS

Please write clearly in block capitals.

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

Surname _____

Forename(s) _____

Candidate signature _____

I declare this is my own work.

INTERNATIONAL A-LEVEL

CHEMISTRY (9620)

Unit 5: Practical and synoptic

Wednesday 18 January 2023 07:00 GMT Time allowed: 1 hour 25 minutes

Materials

For this paper you must have:

- the Periodic Table/Data Sheet, provided as an insert
- 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 this 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.
- If you need extra space for your answer(s), use the lined pages at the end of this book. Write the question number against your answer(s).
- 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 60.

For Examiner's Use	
Question	Mark
1	
2	
3	
4–33	
TOTAL	

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Section A

Answer **all** questions in the spaces provided.

0 1 A student investigated the enthalpy change for the reaction between zinc and copper(II) sulfate solution.

The ionic equation for the reaction is

$$Zn(s) + Cu^{2+}(aq) \longrightarrow Zn^{2+}(aq) + Cu(s)$$

0 1 . 1 The student added some copper(II) sulfate solution to a beaker.

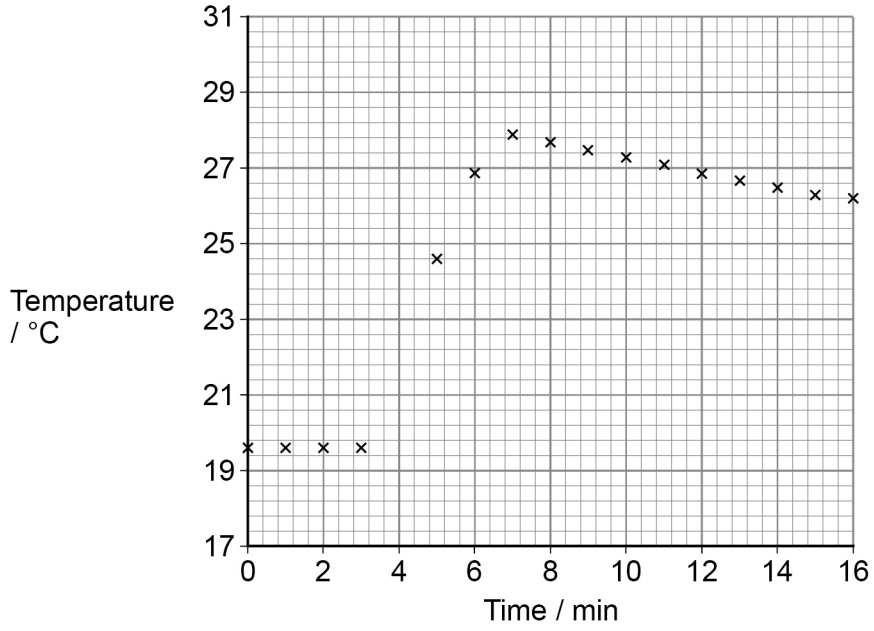
The student recorded the temperature of the solution each minute for three minutes.

At the fourth minute, the student added some zinc powder and stirred the mixture.

The student recorded the temperature at the fifth minute and each minute afterwards for several minutes.

Figure 1 shows the results.

Figure 1



Use **Figure 1** to find the temperature rise, ΔT, at the fourth minute.

Show your working on the graph by drawing suitable lines of best fit.

[2 marks]

ΔT _____ °C

Do not write outside the box

0 1 . 2 The student used an excess of copper(II) sulfate solution in the beaker.

At the fourth minute, the student added 0.34 g of zinc powder.

Use your answer to Question **01.1** to calculate the enthalpy change, in kJ mol^{-1}, for this reaction.

Give your answer to an appropriate number of significant figures.

Assume that, after the reaction, the solution had a mass of 25 g
The specific heat capacity of this solution = 4.18 J K^{-1} g^{-1}

(If you were unable to answer Question **01.1**, use a value of 12 °C for the temperature rise. This is **not** the correct value.)

[4 marks]

Enthalpy change _____ kJ mol^{-1}

Turn over ►

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0 1 . 3 Suggest **two** reasons why it is more accurate to determine the temperature rise using the graph in **Figure 1** rather than measuring the temperature rise at the fourth minute.

[2 marks]

Reason 1 _____

_____

_____

Reason 2 _____

_____

_____

0 1 . 4 In Question **01.2** the student added 0.34 g of zinc powder.

The total uncertainty in the mass of zinc is ±0.01 g

Calculate the percentage uncertainty in the value for the mass of zinc.

[1 mark]

Percentage uncertainty _____

0 1 . 5 The enthalpy change for the reaction between magnesium and an excess of copper(II) sulfate solution is more exothermic than the enthalpy change for the reaction between zinc and an excess of copper(II) sulfate.

$$Mg(s) + Cu^{2+}(aq) \longrightarrow Mg^{2+}(aq) + Cu(s)$$

Suggest **one** reason for the difference between the enthalpy changes.

[1 mark]

_____

_____

_____

10

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Turn over for the next question

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ANSWER IN THE SPACES PROVIDED

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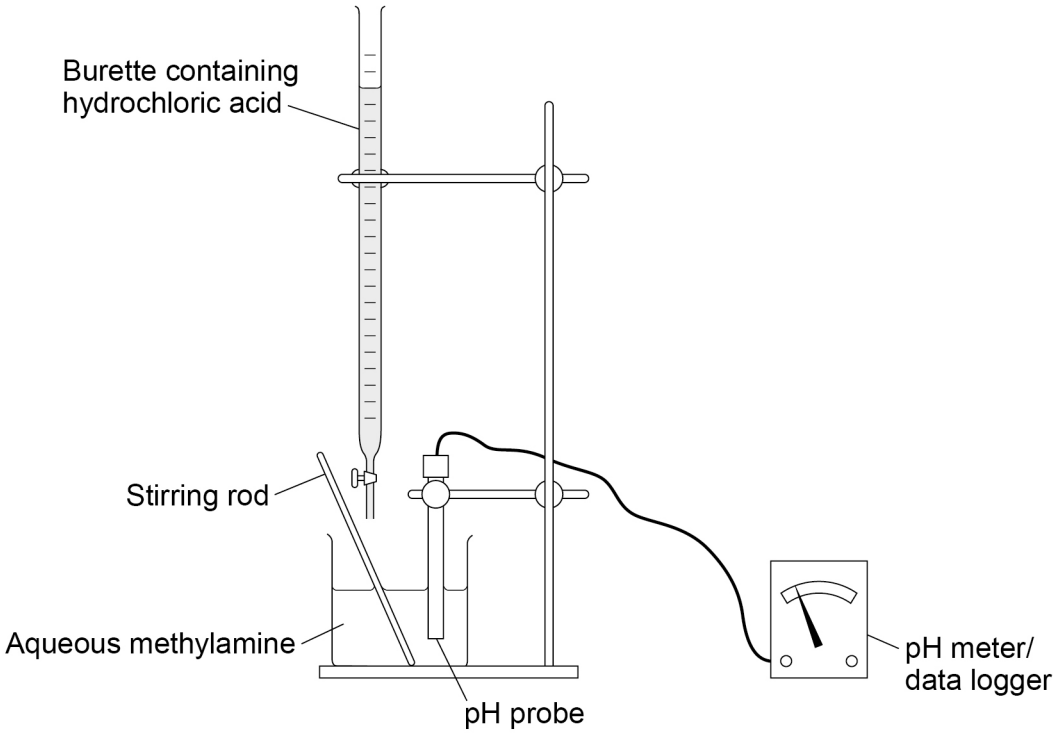
0 2 **Figure 2** shows apparatus to measure the pH as hydrochloric acid is added to aqueous methylamine.

Figure 2



0 2 . 1 25.0 cm^3 of aqueous methylamine are added to the beaker.

Name the piece of apparatus used to add 25.0 cm^3 of aqueous methylamine to the beaker.

[1 mark]

0 2 . 2 The pH meter is calibrated by

- washing the pH probe with distilled water
- washing the pH probe with a small volume of a buffer solution
- measuring the pH of the buffer solution.

This calibration is repeated with two other buffer solutions with different pH values.

State why the probe must be washed with a small volume of buffer solution before measuring the pH of the buffer solution.

[1 mark]

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Question 2 continues on the next page

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ANSWER IN THE SPACES PROVIDED

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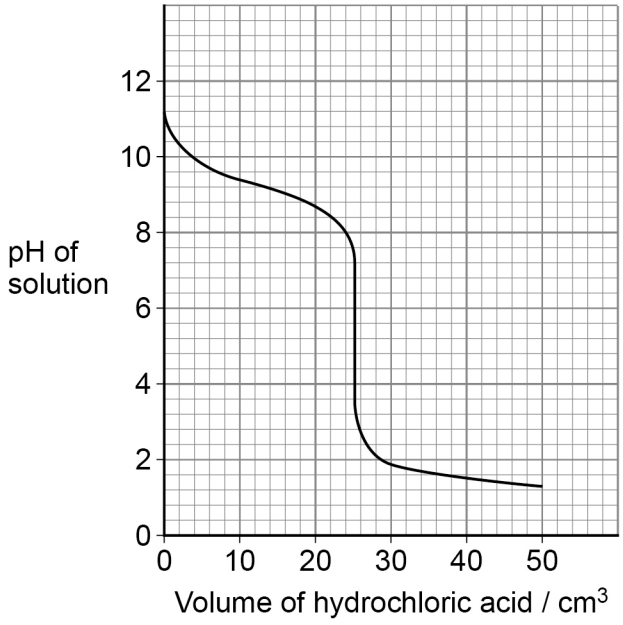
0 2 . 3 The pH probe is placed in the aqueous methylamine in the beaker.
A small volume of hydrochloric acid is added from the burette.
The mixture is stirred and the pH is measured.
Further small volumes of hydrochloric acid are added and the pH is measured after each addition.

Suggest why the pH probe should **not** be washed with distilled water after each addition of acid.

[1 mark]

Figure 3 shows how the pH of the solution changes as hydrochloric acid is added.

Figure 3



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The reaction is repeated without the pH probe.
Hydrochloric acid is titrated into a conical flask containing aqueous methylamine.
An indicator is used to show the end point.

0 2 . 4 Use **Figure 3** to help you identify the most suitable indicator, **A**, **B**, or **C**, to use in this titration.

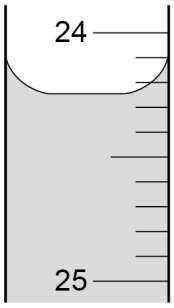
Put a tick (✓) in the correct box.

[1 mark]

Indicator	pH range of indicator	Tick (✓) the most suitable indicator
A	7.5–9.0	
B	3.8–5.4	
C	1.2–2.8	

0 2 . 5 **Figure 4** shows the solution level in the burette at one stage of the titration.

Figure 4



Give the reading shown on the burette in **Figure 4**.

[1 mark]

_____ cm^3

Question 2 continues on the next page

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Just before the end point of the titration, the inside of the conical flask is washed with distilled water. The washings remain in the conical flask.

0 2 . 6 State how this improves the accuracy of the end point.

[1 mark]

0 2 . 7 State why this added water does **not** change the volume of acid needed.

[1 mark]

7

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0 3 This question is about making a pure, dry sample of benzenecarboxylic acid.

Ethyl benzenecarboxylate is hydrolysed by reaction with aqueous sodium hydroxide to form a solution.

$$C_6H_5COOCH_2CH_3 + NaOH \rightarrow C_6H_5COONa + CH_3CH_2OH$$

Hydrochloric acid is added to this solution and a precipitate of benzenecarboxylic acid forms.

$$C_6H_5COONa(aq) + HCl(aq) \rightarrow C_6H_5COOH(s) + NaCl(aq)$$

The crude solid is filtered off under reduced pressure using a Büchner funnel.

The crude solid is washed with a small volume of cold water while still in the Büchner funnel.

0 3 . 1 Suggest why sodium benzenecarboxylate is soluble in cold water.

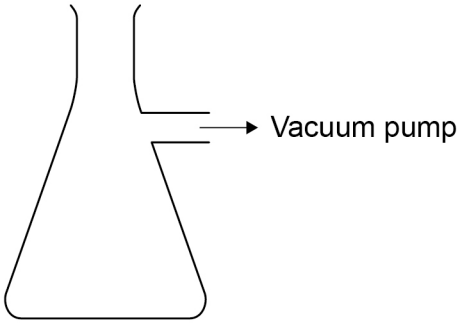
[1 mark]

0 3 . 2 **Figure 5** shows part of the apparatus used to filter off the crude solid.

Complete the diagram.

[2 marks]

Figure 5



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0 3 . 3 Benzenecarboxylic acid is only very slightly soluble in cold water.

Suggest why the crude solid is washed with a small volume of cold water.

[1 mark]

The crude benzenecarboxylic acid is purified by recrystallisation.

The minimum volume of very hot water is used to dissolve the crude solid in a conical flask.

The solution in the conical flask is allowed to cool slowly to room temperature.

The conical flask is then placed in an ice bath.

0 3 . 4 Suggest why the solution is allowed to cool slowly to room temperature.

[1 mark]

0 3 . 5 Suggest why the conical flask is placed in an ice bath after the solution has cooled to room temperature.

[1 mark]

0 3 . 6 The crystals are collected from the solution by filtration under reduced pressure.

Other than the speed of the filtration, give **one** reason why filtration under reduced pressure is used to collect the crystals.

[1 mark]

Do not write outside the box

0 3 . 7 A student tries to obtain the maximum mass of crystals and uses a spatula to remove all the solid from the filter paper.

State why the student should be careful when removing the solid from the filter paper.

[1 mark]

0 3 . 8 In an experiment using 5.60 cm^3 of $C_6H_5COOCH_2CH_3$ (M_r = 150.0), the mass of C_6H_5COOH obtained is 2.80 g

Calculate the percentage yield of C_6H_5COOH

The density of $C_6H_5COOCH_2CH_3$ = 1.05 g cm^{-3}

[3 marks]

Yield _____ %

0 3 . 9 The melting point of the pure, dry crystals is measured.

State **two** observations about the melting point of the sample that show that the sample is pure benzenecarboxylic acid.

[2 marks]

Observation 1 _____

Observation 2 _____

13

Turn over ►

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Section B

Each question is followed by four responses, **A**, **B**, **C** and **D**.

For each question select the best response.

Only **one** answer per question is allowed.
For each question 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.

0 4 What is the definition of relative molecular mass?

[1 mark]

A mass of one molecule compared to the mass of one molecule of ^{12}C ⬭

B $\dfrac{\text{mass of one molecule}}{\frac{1}{12}\text{ mass of one atom of } ^{12}C}$ ⬭

C average mass of a molecule compared to $\frac{1}{12}$ mass of one atom of ^{12}C ⬭

D $\dfrac{\text{mass of one molecule}}{\frac{1}{12}\text{ mass of } ^{12}C}$ ⬭

Do not write outside the box

0 5 What is the formula of chromium(VI) phosphate?

[1 mark]

A $Cr(PO_4)_2$ ⬭

B $Cr(PO_4)_6$ ⬭

C $Cr_3(PO_4)_4$ ⬭

D $Cr_6(PO_4)_3$ ⬭

0 6 Which is true during the evaporation of ethanol?

[1 mark]

A Covalent bonds in the molecules are broken. ⬭

B Intermolecular forces are broken. ⬭

C Hydrogen bonding increases. ⬭

D The degree of disorder of the molecules is decreased. ⬭

0 7 Which molecule is polar?

[1 mark]

A AsF_5 ⬭

B GeF_4 ⬭

C GaF_3 ⬭

D SeF_2 ⬭

Do not write outside the box

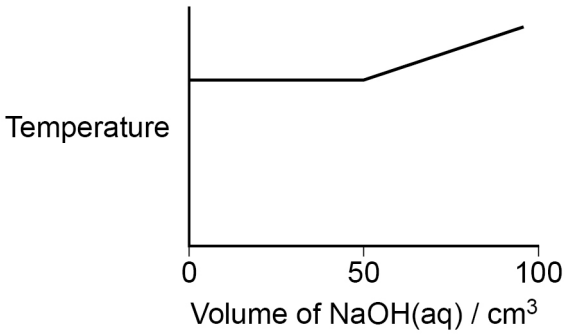
0 8 1 mol dm^{-3} sodium hydroxide solution is added gradually to 50 cm^3 of 1 mol dm^{-3} hydrochloric acid.
Both solutions are initially at the same temperature.

$$H^+(aq) + OH^-(aq) \rightarrow H_2O(l) \qquad \Delta H = -57 \text{ kJ mol}^{-1}$$

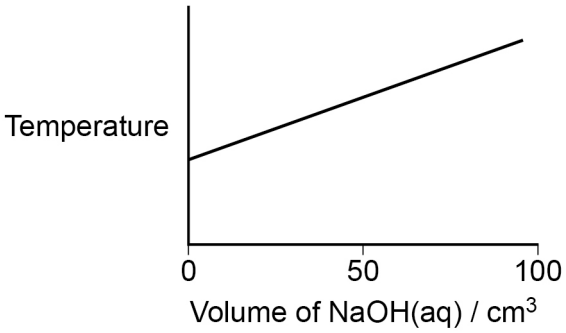
Which graph shows the temperature as the NaOH is added?

[1 mark]

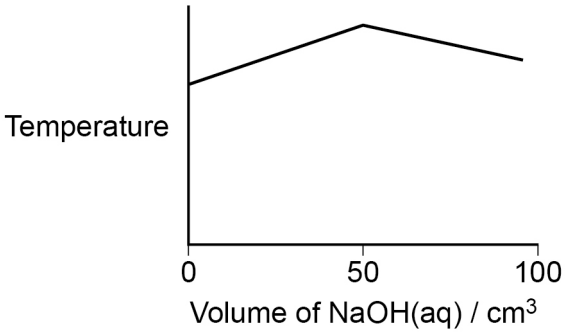
A



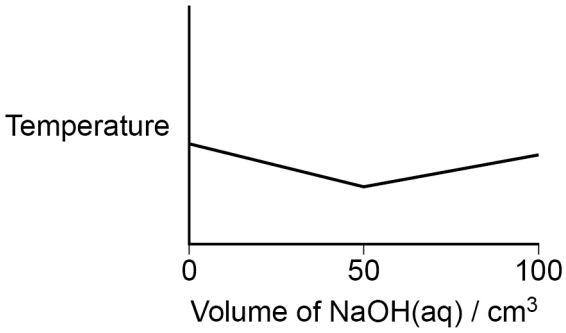
B



C



D



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0 9 Which is **not** a redox reaction?

[1 mark]

A $Br_2 + SO_2 + 2\,H_2O \rightarrow 2\,Br^- + SO_4^{2-} + 4\,H^+$ ⬭

B $Cr_2O_7^{2-} + H_2O \rightarrow 2\,CrO_4^{2-} + 2\,H^+$ ⬭

C $Cu_2O + H_2SO_4 \rightarrow CuSO_4 + Cu + H_2O$ ⬭

D $SnCl_2 + HgCl_2 \rightarrow Hg + SnCl_4$ ⬭

1 0 Calcium carbonate and hydrochloric acid react together.

$$CaCO_3(s) + 2\,HCl(aq) \rightarrow CaCl_2(aq) + H_2O(l) + CO_2(g)$$

The student measured the time for *x* g of calcium carbonate to disappear when reacted with hydrochloric acid.

Which change to the method of the experiment would reduce the percentage error in the time measured?

[1 mark]

A Use a higher temperature. ⬭

B Use a lower concentration of hydrochloric acid. ⬭

C Use larger volumes of hydrochloric acid. ⬭

D Use smaller calcium carbonate pieces. ⬭

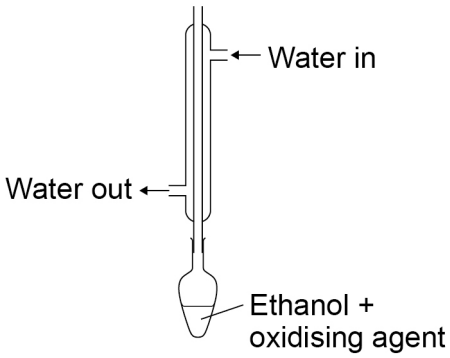
Turn over for the next question

Do not write outside the box

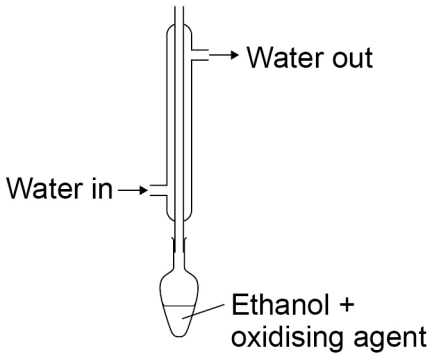
1 1 Which diagram shows the correct apparatus for the conversion of ethanol into ethanoic acid?

[1 mark]

A



B



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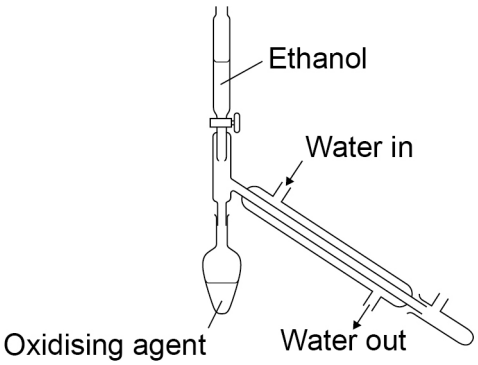
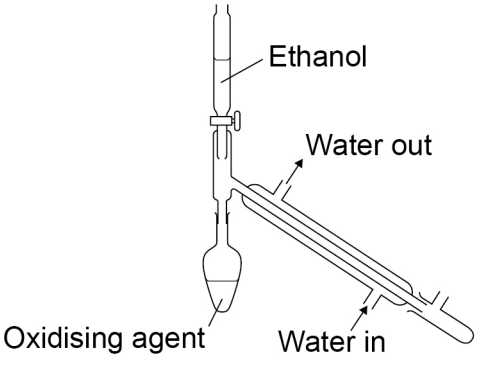


D



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1 2 Which statement is correct about this equilibrium?

$3\,P + Q \rightleftharpoons 2\,R + S \quad \Delta H = +50\ kJ\ mol^{-1}$

[1 mark]

	Change in [P] and [Q]	Change in temperature	Effect on K_c	
A	Increase	No change	Increase	⬭
B	No change	Decrease	No change	⬭
C	Decrease	Increase	Decrease	⬭
D	No change	Decrease	Decrease	⬭

1 3 An electrochemical cell has the conventional cell representation

$Fe(s) \mid Fe^{2+}(aq) \parallel Ag^{+}(aq) \mid Ag(s)$

	$E^{\ominus}$ / V
$Ag^{2+}(aq) + e^{-} \rightarrow Ag^{+}(aq)$	+1.98
$Ag^{+}(aq) + e^{-} \rightarrow Ag(s)$	+0.80
$Fe^{3+}(aq) + e^{-} \rightarrow Fe^{2+}(aq)$	+0.77
$Fe^{2+}(aq) + 2\,e^{-} \rightarrow Fe(s)$	–0.44

What is the EMF of the cell?

[1 mark]

A 1.21 V ⬭

B 1.24 V ⬭

C 1.57 V ⬭

D 2.42 V ⬭

Do not write outside the box

1 4 Some rechargeable cells make use of the chemistry of nickel and cadmium.
The two half equations are:

$$Cd(OH)_2(s) + 2e^- \rightarrow Cd(s) + 2OH^-(aq)$$

$$NiO(OH)(s) + H_2O(l) + e^- \rightarrow Ni(OH)_2(s) + OH^-(aq)$$

During the charging process, Cd^{2+} is reduced to Cd

Which of these is the combined equation for the reaction that happens when the cell is being charged?

[1 mark]

A $Cd(s) + NiO(OH)(s) + H_2O(l) \rightarrow Ni(OH)_2(s) + Cd(OH)_2(s)$ ⬭

B $Cd(s) + 2NiO(OH)(s) + 2H_2O(l) \rightarrow 2Ni(OH)_2(s) + Cd(OH)_2(s)$ ⬭

C $Cd(OH)_2(s) + Ni(OH)_2(s) \rightarrow NiO(OH)(s) + Cd(s) + H_2O(l)$ ⬭

D $Cd(OH)_2(s) + 2Ni(OH)_2(s) \rightarrow 2NiO(OH)(s) + Cd(s) + 2H_2O(l)$ ⬭

1 5 The Arrhenius equation can be rearranged as

$$\ln k = -\frac{E_a}{RT} + \ln A$$

The gradient of a graph of ln k against $\frac{1}{T}$ can be used to calculate the activation energy of a reaction.

Which is the gradient of the graph for a reaction with $E_a = 141\ kJ\ mol^{-1}$?
$R = 8.31\ J\ mol^{-1}\ K^{-1}$

[1 mark]

A -1.7×10^4 ⬭

B -1.7×10^1 ⬭

C -5.9×10^{-2} ⬭

D -5.9×10^{-5} ⬭

Do not write outside the box

1 6 The balanced equation and the rate equation for a reaction are shown.

$$X + 2Y \rightarrow 2Z$$

$$\text{rate} = k[X]^2[H^+]$$

Which statement is correct?

[1 mark]

A A decrease in pH from 2 to 1 causes the reaction rate to double. ⬭

B An increase in concentration of X by a factor of three increases the rate six times. ⬭

C Hydrogen ions act as a catalyst in this reaction. ⬭

D The rate determining step involves Y. ⬭

1 7 Which is the most suitable reagent to detect carbonate ions in a solution of sodium sulfate(VI)?

[1 mark]

A $BaCl_2(aq)$ ⬭

B Dilute $H_2SO_4(aq)$ ⬭

C $NH_3(aq)$ ⬭

D Dilute NaOH(aq) ⬭

1 8 Which statement about calcium hydroxide is correct?

[1 mark]

A It has $M_r = 57.1$ ⬭

B It is used in agriculture to raise soil pH ⬭

C It is used in limewater to test for carbon monoxide. ⬭

D It is used in medicine to neutralise stomach acid. ⬭

Do not write outside the box

1 9 Which statement is correct about this reaction?

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

[1 mark]

A The coordination number of nickel changes from 6 to 3 ⬭

B The entropy change is negative. ⬭

C The nickel 2+ ion in each complex has a d^{10} configuration. ⬭

D The enthalpy change is almost zero. ⬭

2 0 The d electrons in a transition metal complex are excited from the ground state to an excited state when light of wavelength 460 nm is absorbed.

What is the energy difference between the ground state and the excited state of the transition metal ion?

Planck constant (h) = 6.63×10^{-34} J s
Speed of light (c) = 3.00×10^{8} m s^{-1}

[1 mark]

A 1.02×10^{-48} J ⬭

B 1.02×10^{-39} J ⬭

C 4.32×10^{-28} J ⬭

D 4.32×10^{-19} J ⬭

Do not write outside the box

2 1 Iron(II) ions catalyse the reaction between iodide ions and $S_2O_8^{2-}$ ions.

Which equation correctly shows a step in the overall mechanism of this catalysed reaction?

[1 mark]

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

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

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

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

2 2 Which reaction will occur?

[1 mark]

A $[Cu(H_2O)_6]^{2+}(aq) + 6NH_3(aq) \rightarrow [Cu(NH_3)_6]^{2+}(aq) + 6H_2O(l)$ ⬭

B $AgI(s) + 2NH_3(aq) \rightarrow [Ag(NH_3)_2]^+(aq) + I^-(aq)$ ⬭

C $2[Fe(H_2O)_6]^{3+}(aq) + 3CO_3^{2-}(aq) \rightarrow Fe_2(CO_3)_3(s) + 12H_2O(l)$ ⬭

D $NaF(s) + H_2SO_4(aq) \rightarrow HF(g) + NaHSO_4(aq)$ ⬭

2 3 Which is correct?

[1 mark]

A V_2O_5 is a homogeneous catalyst in the Contact process. ⬭

B A support medium can be used to minimise the cost of a heterogeneous catalyst. ⬭

C A heterogeneous catalyst is in the same phase as the reactants. ⬭

D Reactions occur at active sites on homogeneous catalysts. ⬭

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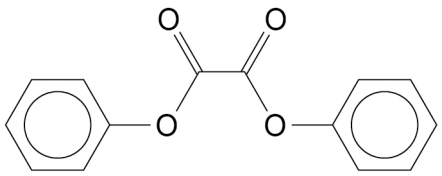
2 4 What is the molecular formula of this organic compound?



[1 mark]

A $C_{12}H_{12}O_4$ ⬭

B $C_{12}H_{10}O_4$ ⬭

C $C_{14}H_{12}O_4$ ⬭

D $C_{14}H_{10}O_4$ ⬭

2 5 The complete combustion of a hydrocarbon produces 8.8 g of carbon dioxide and 3.6 g of water.

What is the empirical formula of the hydrocarbon?

[1 mark]

A CH ⬭

B CH_2 ⬭

C CH_4 ⬭

D C_2H_4 ⬭

Do not write outside the box

2 6 The rate of hydrolysis was investigated by adding aqueous silver nitrate to samples of 1-chloropropane, 1-bromopropane and 1-iodopropane.
Each sample was in its own test tube.

All the experiments were done at the same temperature and started at the same time.

In what order would the coloured precipitates be seen?

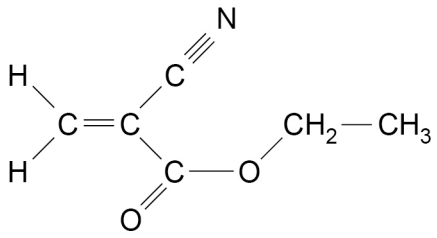
[1 mark]

	First precipitate to be seen	Second precipitate to be seen	Last precipitate to be seen	
A	white	cream	yellow	⬭
B	cream	white	yellow	⬭
C	yellow	white	cream	⬭
D	yellow	cream	white	⬭

Turn over for the next question

Do not write outside the box

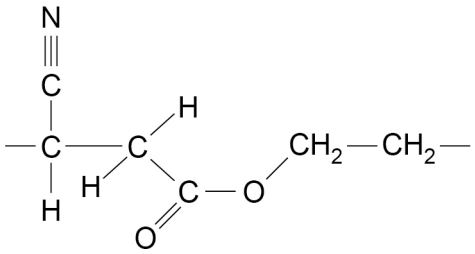
2 7 The structure of one monomer used in a glue is shown.



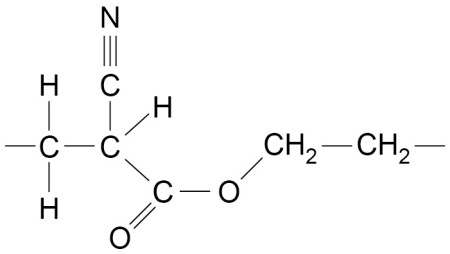
Which is the correct repeating unit of the addition polymer formed from this monomer?

[1 mark]

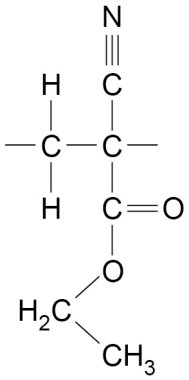
A



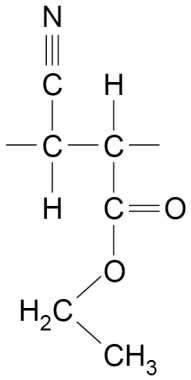
B



C



D



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2 8 Benzene and methylbenzene react with chlorine in ultraviolet light.

Which statement about these reactions in ultraviolet light is correct?

[1 mark]

A (Chloromethyl)benzene is formed when chlorine reacts with methylbenzene. ⬭

B Chlorine reacts with methylbenzene by a free radical addition mechanism. ⬭

C Chlorine reacts with benzene by a free radical substitution mechanism. ⬭

D Hydrogen chloride is a major product when chlorine reacts with benzene. ⬭

Turn over for the next question

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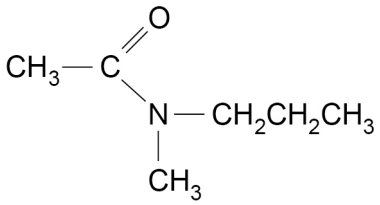
2 9 Which shows the structure of N-ethyl-N-methylpropanamide?

[1 mark]

A



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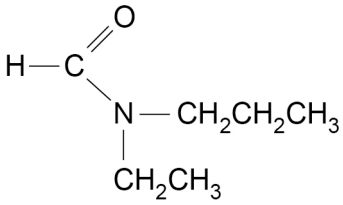

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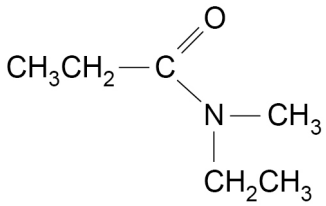

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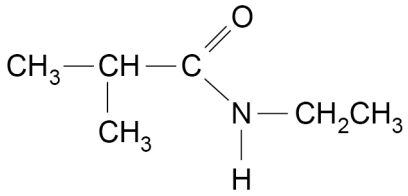
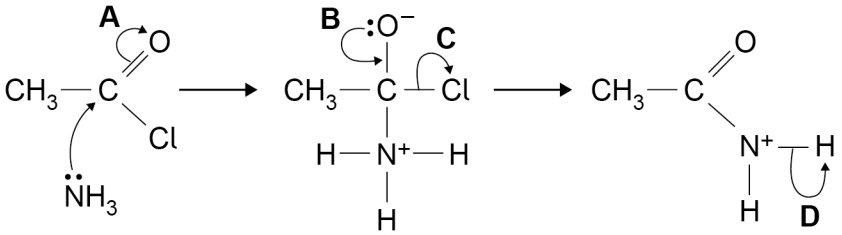


3 0 Which curly arrow is used **incorrectly** in this mechanism?



[1 mark]

A

B

C

D

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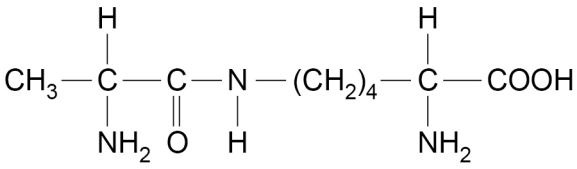
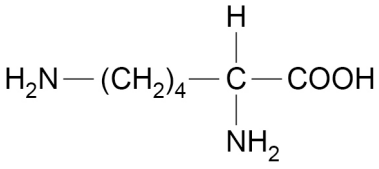
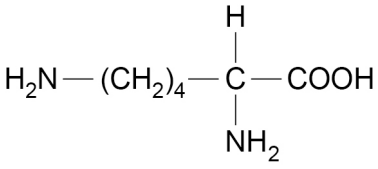
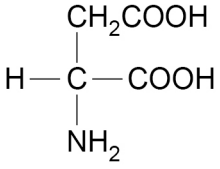
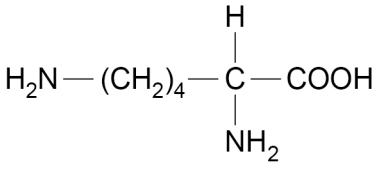
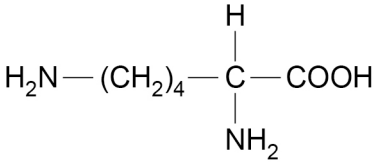
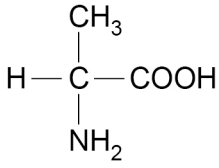
3 1 Which two amino acids would be produced by the hydrolysis of the peptide shown?

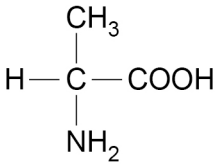
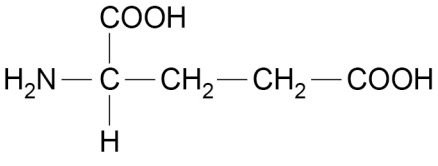


[1 mark]

A  and  ⬭

B  and  ⬭

C  and  ⬭

D  and  ⬭

Turn over for the next question

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3 2 Cisplatin, $[Pt(NH_3)_2Cl_2]$, is used in cancer treatment.

Which statement is correct?

[1 mark]

A Cisplatin prevents replication of DNA in cells. ⬭

B Cisplatin is a tetrahedral complex. ⬭

C Cisplatin acts by preventing energy release in a cell. ⬭

D Cisplatin binds to phosphate residues in DNA. ⬭

3 3 Which react to form an organic product that has only two peaks in its ^1H NMR spectrum?

[1 mark]

A butanal and acidified potassium dichromate(VI) ⬭

B ethanoyl chloride and methanol ⬭

C ethene and hydrogen with a nickel catalyst ⬭

D propanoic acid and ethanol with concentrated sulfuric acid ⬭

30

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