# CHEMISTRY

## UNIT 2(IAL)

2020 — 2025

**1** – (WCH11/2(IAL)_Summer_2020_Q1) – *Energetics, Group Chemistry, Halogenoalkanes And Alcohols*

The bond enthalpy for the Cl—Cl bond is +243.0 kJ mol$^{-1}$.

What is the enthalpy change of atomisation of chlorine in kJ mol$^{-1}$?

☒ **A** +243.0

☒ **B** –243.0

☒ **C** +121.5

☒ **D** –121.5

**2** – (WCH11/2(IAL)_Summer_2020_Q2) – *Energetics, Group Chemistry, Halogenoalkanes And Alcohols*

The standard enthalpy change of neutralisation for the reaction between sodium hydroxide solution and hydrochloric acid is –56 kJ mol$^{-1}$.

Which row in the table is correct for this neutralisation?

| | Reaction type | Temperature |
|---|---|---|
| ☒ **A** | exothermic | increases |
| ☒ **B** | exothermic | decreases |
| ☒ **C** | endothermic | increases |
| ☒ **D** | endothermic | decreases |

**3** – (WCH11/2(IAL)_Summer_2020_Q3) – *Energetics, Group Chemistry, Halogenoalkanes And Alcohols*

Which of the following statements about water is **not** due to hydrogen bonding?

☒ **A** water has a less open structure than ice

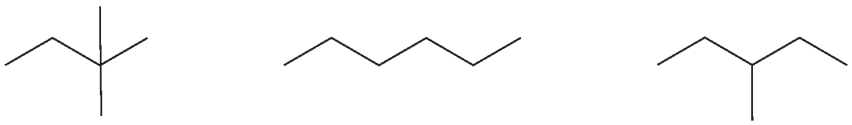
☒ **B** ice cubes float in a glass of iced water

☒ **C** when water freezes its volume increases

☒ **D** water is a good solvent for ionic compounds

**4** – (WCH11/2(IAL)_Summer_2020_Q4) – *Energetics, Group Chemistry, Halogenoalkanes And Alcohols*

The skeletal formulae of three isomers are shown.



X Y Z

Which series shows the correct order of **increasing** boiling temperatures?

☒ **A** Y, X, Z

☒ **B** X, Y, Z

☒ **C** Y, Z, X

☒ **D** X, Z, Y

**5** – (WCH11/2(IAL)_Summer_2020_Q5) – *Energetics, Group Chemistry, Halogenoalkanes And Alcohols*

Hydrogen peroxide decomposes in the presence of a catalyst.

$$2H_2O_2(aq) \rightarrow 2H_2O(l) + O_2(g)$$

(a) What type of reaction occurs?

**(1)**

☒ **A** displacement

☒ **B** disproportionation

☒ **C** elimination

☒ **D** hydrolysis

(b) In an experiment, the volume of oxygen produced by the decomposition of hydrogen peroxide was measured at various times as the reaction progressed and a graph was plotted.

The initial gradient of the graph was $0.50\,cm^3\,s^{-1}$.

What is the initial rate of decomposition of hydrogen peroxide in $mol\,s^{-1}$?

[Molar volume of a gas at r.t.p. = $24\,dm^3\,mol^{-1}$]

**(1)**

☒ **A** $2.1 \times 10^{-2}\,mol\,s^{-1}$

☒ **B** $4.2 \times 10^{-5}\,mol\,s^{-1}$

☒ **C** $2.1 \times 10^{-5}\,mol\,s^{-1}$

☒ **D** $1.0 \times 10^{-5}\,mol\,s^{-1}$

**6** - (WCH11/2(IAL)_Summer_2020_Q6) - *Energetics, Group Chemistry, Halogenoalkanes And Alcohols*

Dichromate(VI) ions may be reduced in acidic solution.

$$Cr_2O_7^{2-}(aq) + x\,H^+(aq) + y\,e^- \rightarrow 2Cr^{3+}(aq) + z\,H_2O(l)$$

The coefficients in this half-equation are

| | x | y | z |
|---|---|---|---|
| ☒ **A** | 14 | 6 | 7 |
| ☒ **B** | 14 | 3 | 7 |
| ☒ **C** | 7 | 6 | 3.5 |
| ☒ **D** | 7 | 3 | 3.5 |

**7** - (WCH11/2(IAL)_Summer_2020_Q7) - *Energetics, Group Chemistry, Halogenoalkanes And Alcohols*

In an oxide of potassium, the oxidation number of oxygen is –½.

What is the formula of this oxide?

☒ **A** $K_2O$

☒ **B** $K_2O_2$

☒ **C** $K_2O_3$

☒ **D** $KO_2$

**8** – (WCH11/2(IAL)_Summer_2020_Q8) – *Energetics, Group Chemistry, Halogenoalkanes And Alcohols*

Compound **Q** gives off nitrogen dioxide when heated, and produces a red colour in a flame test.

(a) Which of these compounds could be **Q**?

**(1)**

☒ **A** barium nitrate

☒ **B** lithium nitrate

☒ **C** magnesium nitrate

☒ **D** rubidium nitrate

(b) Which colour and test results are correct for nitrogen dioxide gas?

**(1)**

| | Colour of nitrogen dioxide | Colour change of damp litmus paper |
|---|---|---|
| ☒ **A** | brown | blue to red |
| ☒ **B** | brown | red to blue |
| ☒ **C** | colourless | blue to red |
| ☒ **D** | colourless | red to blue |

**9** – (WCH11/2(IAL)_Summer_2020_Q9) – *Energetics, Group Chemistry, Halogenoalkanes And Alcohols*

The products of the reaction of sodium fluoride with concentrated sulfuric acid can be predicted by considering the trends for the other sodium halides.

Which gas or gases form when sodium fluoride reacts with concentrated sulfuric acid?

☒ **A** hydrogen fluoride only

☒ **B** hydrogen fluoride and fluorine only

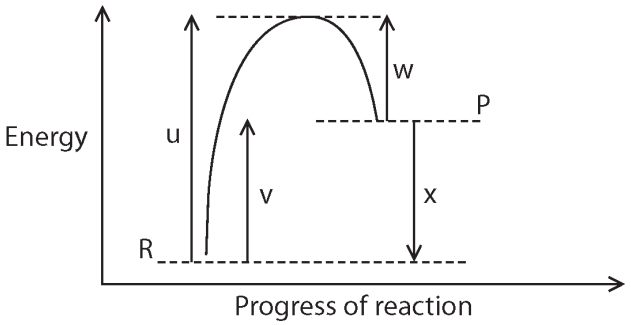
☒ **C** hydrogen fluoride and sulfur dioxide only

☒ **D** hydrogen fluoride, fluorine and sulfur dioxide only

**10** – (WCH11/2(IAL)_Summer_2020_Q10) – *Energetics, Group Chemistry, Halogenoalkanes And Alcohols*

The diagram shows a reaction profile for a reversible reaction.

$$R \rightleftharpoons P$$




(a) Which symbol represents the enthalpy change for the reaction $R \rightarrow P$?

**(1)**

☒ **A** u

☒ **B** v

☒ **C** w

☒ **D** x

(b) Which symbol represents the activation energy of the reaction $P \rightarrow R$?

**(1)**

☒ **A** u

☒ **B** v

☒ **C** w

☒ **D** x

(c) Hess's Law can be applied to this system.

Which expression is correct?

**(1)**

☒ **A** $v + x = u + w$

☒ **B** $w + x = u$

☒ **C** $u - w = v$

☒ **D** $u - v = x$

**11** – (WCH11/2(IAL)_Summer_2020_Q11) – *Energetics, Group Chemistry, Halogenoalkanes And Alcohols*

A solution containing 0.100 mol of hydrochloric acid is added to 8.43 g of magnesium carbonate.

$$MgCO_3(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + CO_2(g) + H_2O(l)$$

(a) What is the total volume (at r.t.p.) of carbon dioxide formed?

[$M_r(MgCO_3) = 84.3$ Molar volume of a gas at r.t.p. = 24.0 $dm^3\ mol^{-1}$]

**(1)**

☒ **A** 2.40 $dm^3$

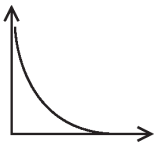
☒ **B** 1.20 $dm^3$

☒ **C** 2400 $dm^3$

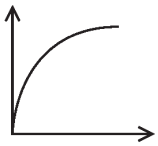
☒ **D** 1200 $dm^3$

(b) Which sketch graph shows the volume of carbon dioxide (*y*-axis) plotted against time (*x*-axis) during the reaction?

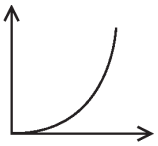
**(1)**



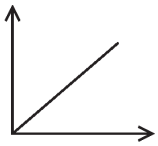
☒ **A**



☒ **B**



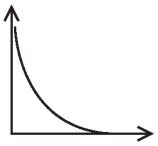
☒ **C**



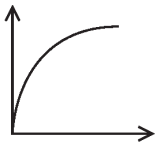
☒ **D**

(c) Which sketch graph shows the rate of the reaction (*y*-axis) plotted against time (*x*-axis) during the reaction?

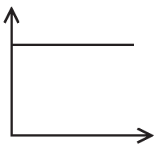
**(1)**



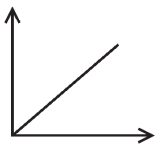
☒ **A**



☒ **B**



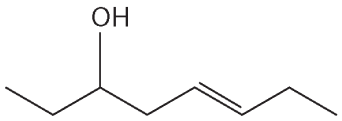
☒ **C**



☒ **D**

**12** – (WCH11/2(IAL)_Summer_2020_Q12) – *Energetics, Group Chemistry, Halogenoalkanes And Alcohols*

(a) What is the name of compound L?




L

**(1)**

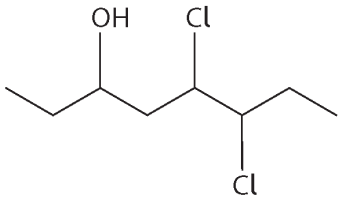
☒ **A** *Z*-oct-3-en-3-ol

☒ **B** *E*-oct-3-en-3-ol

☒ **C** *Z*-oct-5-en-3-ol

☒ **D** *E*-oct-5-en-3-ol

(b) Compound L can be converted into compound M.




M

Which reagent should be used?

**(1)**

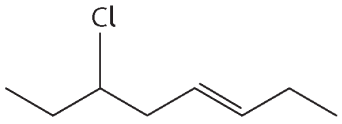
☒ **A** $Cl_2(g)$

☒ **B** HCl(g)

☒ **C** $PCl_5(s)$

☒ **D** KCl(aq)

(c) Compound L can also be converted into compound N.




N

Which reagent should be used?

**(1)**

☒ **A** $Cl_2(g)$

☒ **B** HCl(g)

☒ **C** $PCl_5(s)$

☒ **D** KCl(aq)

**13** – (WCH11/2(IAL)_Summer_2020_Q13) – *Energetics, Group Chemistry, Halogenoalkanes And Alcohols*

Enthalpy changes of formation are often difficult to determine directly.

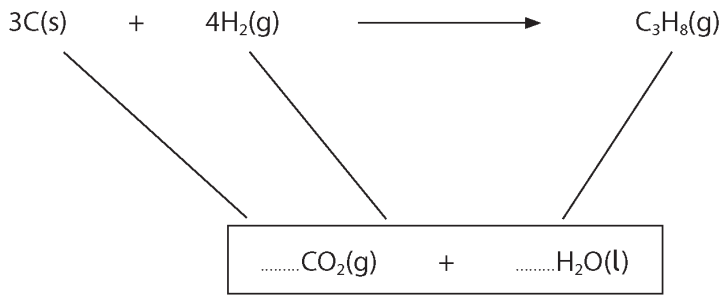
Some enthalpy data are shown.

| Compound | Standard enthalpy change of formation, $\Delta_f H^{\ominus}$ / kJ mol$^{-1}$ |
|---|---|
| $H_2O(l)$ | –285.8 |
| $CO_2(g)$ | –393.5 |

Standard enthalpy change of combustion of propane ($\Delta_c H^{\ominus}$ ($C_3H_8$)) = –2219 kJ mol$^{-1}$.

(a) (i) Add arrowheads and stoichiometric coefficients to the Hess's Law diagram.

**(1)**




(ii) Use the data at the start of the question and your Hess's Law diagram to calculate the standard enthalpy change of formation of propane.
Include a sign and units in your answer.

**(2)**

(b) The values for the boiling temperatures and the standard enthalpies of combustion of a series of straight-chain alkanes are shown in the table.

| Alkane | Boiling temperature / °C | Standard enthalpy change of combustion, $\Delta_c H^{\ominus}$ / kJ mol$^{-1}$ | Increase in $\Delta_c H^{\ominus}$ / kJ mol$^{-1}$ |
|---|---|---|---|
| $C_2H_6$ | –88.5 | –1560 | – |
| $C_3H_8$ | –42.0 | –2219 | 659 |
| $C_4H_{10}$ | –0.5 | –2877 | 658 |
| $C_5H_{12}$ | 36.1 | –3509 | 632 |
| $C_6H_{14}$ | 68.8 | –4163 | 654 |
| $C_7H_{16}$ | 98.4 | –4817 | 654 |

(i) Explain why the increases in the values of $\Delta_c H^{\ominus}$ are similar.

**(2)**

(ii) The increase in the value of $\Delta_c H^{\ominus}$ from butane to pentane is smaller than any other increase.

Suggest an explanation for this.

**(2)**

(iii) Explain, with reference to their intermolecular forces, why the boiling temperatures of **alkanes** increase as the number of carbon atoms increases. A detailed description of the intermolecular forces is not required.

**(3)**

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**14** – (WCH11/2(IAL)_Summer_2020_Q14) – *Energetics, Group Chemistry, Halogenoalkanes And Alcohols*

Limewater is a solution of calcium hydroxide used in the laboratory to test for carbon dioxide.

(a) Write the equation for the formation of the white precipitate in this test. Include state symbols.

**(2)**

(b) The concentration of a saturated solution of calcium hydroxide can be determined by titration.

25.0 $cm^3$ portions of a saturated solution of calcium hydroxide were titrated with 0.0500 $mol\,dm^{-3}$ hydrochloric acid using phenolphthalein indicator.
The mean titre was 23.40 $cm^3$.

Calculate the concentration of calcium hydroxide in $g\,dm^{-3}$.
Give your answer to an appropriate number of significant figures.

[$M_r(Ca(OH)_2)$ = 74.1]

**(4)**

(c) The experiment was repeated using the same hydrochloric acid with a saturated solution of magnesium hydroxide.

Explain the difference (if any) in the mean titre.

**(2)**

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**15** – (WCH11/2(IAL)_Summer_2020_Q15) – *Energetics, Group Chemistry, Halogenoalkanes And Alcohols*

(a) Silver ions have anti-microbial properties and are used in some wound dressings. Silver nitrate can be made by warming a mixture of silver metal and concentrated nitric acid.

$$Ag(s) + 2HNO_3(aq) \rightarrow AgNO_3(aq) + NO_2(g) + H_2O(l)$$

Show, by reference to oxidation numbers, that this is a redox reaction.

**(2)**

(b) Two students used different methods to determine the concentration of a silver nitrate solution.

(i) Student A used a calorimetric method, reacting a 50.0 $cm^3$ sample of the solution with excess powdered zinc.

$$AgNO_3(aq) + \tfrac{1}{2}Zn(s) \rightarrow \tfrac{1}{2}Zn(NO_3)_2(aq) + Ag(s) \quad \Delta_r H = -36.1\ kJ\ mol^{-1}$$

The student recorded a maximum rise in temperature of 5.2 °C.

Calculate the concentration of the silver nitrate solution in mol $dm^{-3}$.

[Assume the specific heat capacity of the solution is 4.18 $J\ g^{-1}\ °C^{-1}$ and the density of the solution is 1.00 $g\ cm^{-3}$.]

**(3)**

(ii) Student B used a gravimetric method, which involved weighing a product of a reaction.

A 50.0 $cm^3$ sample of the same silver nitrate solution was mixed with excess potassium bromide solution. The precipitate was filtered and weighed.

$$AgNO_3(aq) + KBr(aq) \rightarrow AgBr(s) + KNO_3(aq)$$

The mass of the precipitate was found to be 5.96 g.

Calculate the concentration of the silver nitrate solution, in mol $dm^{-3}$, from this gravimetric method.

**(2)**

(iii) The students' values were different from the data book value.
Student A's value was lower and student B's value was higher.
Give a possible reason for each difference.

**(2)**

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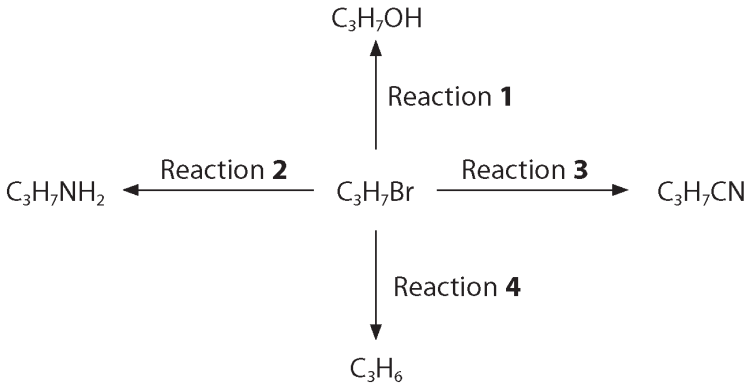
**16** – (WCH11/2(IAL)_Summer_2020_Q16) – *Energetics, Group Chemistry, Halogenoalkanes And Alcohols*

Halogenoalkanes are useful reagents in organic synthesis.

Some reactions of 1-bromopropane are shown.




(a) Complete the table about these reactions.

**(4)**

| Reaction | Reagent | Solvent | Type of reaction |
|---|---|---|---|
| **1** | potassium hydroxide | | |
| **2** | ammonia | | |
| **3** | | ethanol | |
| **4** | | | elimination |

(b) Give the IUPAC name of the product of Reaction **3**.

**(1)**

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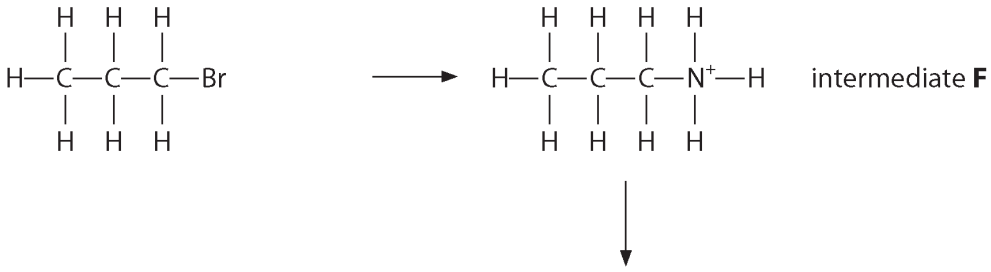
(c) Complete the mechanism for Reaction **2**.
Show the formation of the intermediate **F** and of the product.
Include curly arrows, and any relevant lone pairs and dipoles.

**(3)**



*(d) The relative rates of hydrolysis of a series of halogenoalkanes were determined using the following method:

- five test tubes, each containing 2 $cm^3$ of ethanol and 2 $cm^3$ of aqueous silver nitrate, were placed in a water bath at 50 °C
- four drops of a different halogenoalkane were added to each test tube
- the time taken for a precipitate to appear in each test tube was recorded.

The results are shown.

| Halogenoalkane | Time for ppt to appear / s |
|---|---|
| 2-bromobutane | 29 |
| 2-chlorobutane | 75 |
| 2-iodobutane | <1 |
| 1-bromobutane | 41 |
| 2-bromo-2-methylbutane | 13 |

Explain these results by considering:

- the chemical reaction occurring
- the structures of the halogenoalkanes
- the strengths of the carbon-halogen bonds.

**(6)**

# ANSWERS

**1** – (WCH11/2(IAL)_Summer_2020_Q1) – *Energetics, Group Chemistry, Halogenoalkanes And Alcohols*

C

**2** – (WCH11/2(IAL)_Summer_2020_Q2) – *Energetics, Group Chemistry, Halogenoalkanes And Alcohols*

A

**3** – (WCH11/2(IAL)_Summer_2020_Q3) – *Energetics, Group Chemistry, Halogenoalkanes And Alcohols*

D

**4** – (WCH11/2(IAL)_Summer_2020_Q4) – *Energetics, Group Chemistry, Halogenoalkanes And Alcohols*

D

**5** – (WCH11/2(IAL)_Summer_2020_Q5) – *Energetics, Group Chemistry, Halogenoalkanes And Alcohols*

| Question Number | Answer | Mark |
|---|---|---|
| (a) | **The only correct answer is B** (disproportionation)<br><br>*A is incorrect because no species has been replaced/displaced*<br><br>*C is incorrect because no species has been eliminated*<br><br>*D is incorrect because water is produced and no species is hydrolysed* | **(1)** |

| Question Number | Answer | Mark |
|---|---|---|
| (b) | **The only correct answer is B** ($4.2 \times 10^{-5}$ mol $s^{-1}$)<br><br>*A is incorrect because incorrect units for the Molar Volume of a gas has been used*<br><br>*C is incorrect because the stoichiometry has not been taken into account*<br><br>*D is incorrect because the stoichiometry is incorrect* | **(1)** |

**6** – (WCH11/2(IAL)_Summer_2020_Q6) – *Energetics, Group Chemistry, Halogenoalkanes And Alcohols*

A

**7** – (WCH11/2(IAL)_Summer_2020_Q7) – *Energetics, Group Chemistry, Halogenoalkanes And Alcohols*

D

**8** – (WCH11/2(IAL)_Summer_2020_Q8) – *Energetics, Group Chemistry, Halogenoalkanes And Alcohols*

| Question Number | Answer | Mark |
|---|---|---|
| (a) | **The only correct answer is B** (lithium nitrate)<br><br>*A is incorrect because barium has a green colour in the flame test*<br><br>*C is incorrect because magnesium does not have a red colour in the flame test*<br><br>*D is incorrect because rubidium nitrate does not produce nitrogen dioxide when heated* | **(1)** |

| Question Number | Answer | Mark |
|---|---|---|
| (b) | **The only correct answer is A** (brown and blue to red)<br><br>*B is incorrect because nitrogen dioxide would have no effect on damp red litmus paper*<br><br>*C is incorrect because nitrogen dioxide is brown*<br><br>*D is incorrect because nitrogen dioxide is brown and would have no effect on damp red litmus paper* | **(1)** |

**9** – (WCH11/2(IAL)_Summer_2020_Q9) – *Energetics, Group Chemistry, Halogenoalkanes And Alcohols*

A

**10** – (WCH11/2(IAL)_Summer_2020_Q10) – *Energetics, Group Chemistry, Halogenoalkanes And Alcohols*

| Question Number | Answer | Mark |
|---|---|---|
| (a) | **The only correct answer is B** (v)<br><br>*A is incorrect because u is the activation energy for the reaction R→P*<br><br>*C is incorrect because w is the activation energy for the reaction P→R*<br><br>*D is incorrect because x is the enthalpy change for the reaction P→R* | **(1)** |

| Question Number | Answer | Mark |
|---|---|---|
| (b) | **The only correct answer is C** (w)<br><br>*A is incorrect because u is the activation energy for the reaction R→P*<br><br>*B is incorrect because v is the enthalpy change for the reaction R→P*<br><br>*D is incorrect because x is the enthalpy change for the reaction* P→R | **(1)** |

| Question Number | Answer | Mark |
|---|---|---|
| (c) | **The only correct answer is C** (u −w = v)<br><br>*A is incorrect because v+x =0 and u+w is the sum of the activation energies*<br><br>*B is incorrect because w-x = u*<br><br>*D is incorrect because u-v = w (not x)* | **(1)** |

**11** – (WCH11/2(IAL)_Summer_2020_Q11) – *Energetics, Group Chemistry, Halogenoalkanes And Alcohols*

| Question Number | Answer | Mark |
|---|---|---|
| (a) | **The only correct answer is B** (1.20 $dm^3$)<br><br>*A is incorrect because the limiting factor of the hydrochloric acid has been neglected*<br><br>*C is incorrect because the limiting factor of the hydrochloric acid has been neglected and the answer would be correct if the units were $cm^3$*<br><br>*D is incorrect because the answer would be correct if the units were $cm^3$* | (1) |

| Question Number | Answer | Mark |
|---|---|---|
| (b) | **The only correct answer is B**<br><br>  <br><br>*A is incorrect because the volume of gas is shown decreasing with time*<br><br>*C is incorrect because the gradient is shown increasing with time*<br><br>*D is incorrect because the gradient is shown as constant* | (1) |

| Question Number | Answer | Mark |
|---|---|---|
| (c) | **The only correct answer is A**<br><br>  <br><br>*B is incorrect because the rate is shown increasing with time*<br><br>*C is incorrect because the rate is shown as constant*<br><br>*D is incorrect because the rate is shown increasing with time* | (1) |

**12** – (WCH11/2(IAL)_Summer_2020_Q12) – *Energetics, Group Chemistry, Halogenoalkanes And Alcohols*

| Question Number | Answer | Mark |
|---|---|---|
| (a) | **The only correct answer is D** (*E*-oct-5-en-3-ol)<br><br>*A is incorrect because the wrong priority has been assigned and the E/Z nomenclature is incorrect*<br><br>***B** is incorrect because the wrong priority has been assigned*<br><br>***C** is incorrect because this is the name of the Z isomer* | **(1)** |

| Question Number | Answer | Mark |
|---|---|---|
| (b) | **The only correct answer is A** ($Cl_2(g)$)<br><br>***B** is incorrect because only one chlorine atom would be added*<br><br>***C** is incorrect because $PCl_5$ does not react with a C=C bond*<br><br>***D** is incorrect because potassium chloride does not react with either a C=C bond or -OH group* | **(1)** |

| Question Number | Answer | Mark |
|---|---|---|
| (c) | **The only correct answer is C** ($PCl_5(s)$)<br><br>*A is incorrect because chlorine does not react with an alcohol*<br><br>***B** is incorrect because hydrogen chloride does not react with an alcohol*<br><br>***D** is incorrect because potassium chloride does not react with either a C=C bond or -OH group* | **(1)** |

**13** – (WCH11/2(IAL)_Summer_2020_Q13) – *Energetics, Group Chemistry, Halogenoalkanes And Alcohols*

| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| (a)(i) | All three arrowheads down at any point in/on the line **(1)**<br>AND<br>coefficients are 3 for $CO_2$ **and** 4 for $H_2O$ | | **(1)** |

| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| (a)(ii) | • calculation for enthalpy change on LHS **(1)**<br><br>• correct application of Hess's Law and answer with correct sign **(1)** | Example of calculation;<br>(3 x −393.5 ) + (4 x−285.8) = (−1180.5) + ( − 1143.2) = −2323.7(kJ $mol^{-1}$)<br><br>+2219 -2323.7 = **-**104.7/-105 (kJ $mol^{-1}$)<br><br>Correct answer with sign (2) | **(2)** |

| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| (b)(i) | An explanation that makes reference to the following points:<br>• each alkane differs from the next by -$CH_2$/one carbon atom and two hydrogen atoms/same number of C-C bonds and same number of C-H bonds/ forms a homologous series/ has a general formula $C_nH_{2n+2}$ **(1)**<br><br>• bonds broken and/or made increase regularly/ each -$CH_2$ combusted adds almost the same amount of energy/ bond energies are very similar **(1)** | Ignore references to intermolecular forces/boiling points | **(2)** |

| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| (b)(ii) | An explanation that makes reference to **two** of the following points:<br>• butane is a gas and pentane is a liquid (at 298 K / under standard conditions) **(1)**<br><br>• liquids vaporise before burning/combustion **(1)**<br><br>• (pentane is a liquid so) some of the energy released by combustion is used to vaporise / vaporisation is endothermic<br>OR<br>More energy is needed to break intermolecular forces in pentane or reverse argument **(1)** | Pentane vaporises before combustion **and** butane is (already) a gas would score M1 and M2 | **(2)** |

| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| (b)(iii) | An explanation that makes reference to the following points:<br>• the intermolecular forces are London / dispersion forces / instantaneous dipole – induced dipole forces **(1)**<br>• these forces depend on the number of electrons which increase (as the number of carbon atoms increase) **(1)**<br>• more **energy** is needed to break these intermolecular forces/to separate the molecules (so the boiling temperature increases) **(1)** | Any reference to hydrogen bonding or permanent dipole interaction loses M1 and M2<br>ALLOW: Van der Waals forces for London forces<br>ALLOW: increase in surface area/more points of contact (as the number of carbon atoms increase)<br>Any reference to breaking of covalent bonds loses M3 | **(3)** |

**14 –** (WCH11/2(IAL)_Summer_2020_Q14) **–** *Energetics, Group Chemistry, Halogenoalkanes And Alcohols*

| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| (a) | • balanced equation **(1)**<br>• state symbols correct **(1)** | Example of equation<br>$Ca(OH)_2(aq) + CO_2(g) \rightarrow CaCO_3(s) + H_2O(l)$<br>ALLOW 1 mark for LHS or RHS totally correct | **(2)** |

| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| (b) | • moles of hydrochloric acid in titre **(1)**<br>• moles $Ca(OH)_2$ in 1 $dm^3$ **(1)**<br>• mass $Ca(OH)_2$ in 1 $dm^3$ **(1)**<br>• answer to 2 or 3 SF **(1)** | Example of calculations:<br>$23.40 \times 0.0500 \div 1000 = 0.00117/1.17 \times 10^{-3}$ (moles)<br>$0.00117 \div 2 = 0.000585$ (moles) in 25 $cm^3$<br>$0.000585 \times 1000 \div 25 = 0.0234/2.34 \times 10^{-2}$ (moles/moles $dm^{-3}$)<br>$0.0234 \times 74.1/74 = 1.7339/1.7316$ (g)<br>1.7/1.73 (g $dm^{-3}$) to 2 or 3 SF<br>Penalise incorrect units once only<br>Answer to 2 or3 SF from a calculated mass<br>Correct answer with no working scores 4<br>Allow TE throughout | **(4)** |

| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| (c) | • as magnesium hydroxide is less soluble/concentration of hydroxide ions would be smaller **(1)**<br>• titre value would be smaller **(1)** | Allow reverse argument<br>Do not award magnesium hydroxide is insoluble<br>M2 depends on correct M1 except when magnesium hydroxide is described as insoluble<br>ALLOW a value less than 23.00 | **(2)** |

**15 –** (WCH11/2(IAL)_Summer_2020_Q15) **–** *Energetics, Group Chemistry, Halogenoalkanes And Alcohols*

| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| (a) | • Silver is oxidised from 0 to +1 **(1)**<br>• Nitrogen is reduced from +5 to +4 **(1)** | These may be shown on the equation<br>ALLOW one mark for silver is oxidised **and** nitrogen is reduced or all oxidation numbers correct<br>ALLOW 1 or 1+ for +1 | **(2)** |

| Question Number | Answer | | Additional Guidance | Mark |
|---|---|---|---|---|
| (b)(i) | • calculation of energy change | (1) | Examples of calculation<br>Q = 50.0 ÷ 1000 x 4.18 x 5.2<br>= 1.0868 (kJ)/1086.8(J) | (3) |
| | • calculation of no of moles | (1) | 1.0868 ÷ 36.1 = 0.030105/3.0105 x$10^{-2}$ (moles) | |
| | • calculation of concentration | (1) | 0.030105 ÷ 50 x 1000 = 0.602105(mol $dm^{-3}$)<br>= 0.602/0.60/0.6 (mol $dm^{-3}$)<br>Ignore SF | |

| Question Number | Answer | | Additional Guidance | Mark |
|---|---|---|---|---|
| (b)(ii) | • calculation of moles of ppt | (1) | Example of calculation<br>5.96 ÷ 187.8 = 0.0317359 (moles) | (2) |
| | • calculation of concentration | (1) | 0. 00317359 ÷ 50 x 1000 = 0.634718(mol $dm^{-3}$)<br>Ignore SF except 1 SF<br>ALLOW use of 188 as $M_r$<br>Penalise incorrect rounding once only | |

| Question Number | Answer | | Additional Guidance | Mark |
|---|---|---|---|---|
| (b)(iii) | An explanation that makes reference to:<br>• the calorimetry method (student A) is lower because heat may be lost to the surroundings /absorbed by the container or apparatus | (1) | Do not award: non-standard conditions, just "incomplete reaction", human error, incorrect solution density/heat capacity<br>ALLOW: not all the **solution** reacted | (2) |
| | • the gravimetric method (student B) is higher because the product may have been wet/ have impurities | (1) | | |

**16** – (WCH11/2(IAL)_Summer_2020_Q16) – *Energetics, Group Chemistry, Halogenoalkanes And Alcohols*

| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| (a) | | | (4) |

| Reaction | Reagent | Solvent | Type of reaction | |
|---|---|---|---|---|
| 1 | (potassium Hydroxide) | Water/aqueous | substitution | (1) |
| 2 | (ammonia) | Ethanol/$C_2H_5OH$ | substitution | (1) |
| 3 | sodium/potassium cyanide NaCN/KCN | (ethanol) | substitution | (1) |
| 4 | potassium/sodium hydroxide KOH/NaOH | Ethanol/$C_2H_5OH$ | (elimination) | (1) |

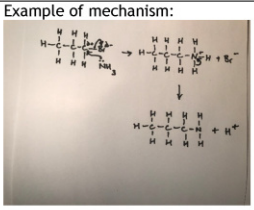
IGNORE nucleophilic in first three reactions but penalise electrophilic/free radical once only
ALLOW alcoholic for reactions 2 and 4

Do not award: cyanide/$CN^-$/HCN

Do not award $OH^-$

8 correct scores 4 marks
6/7 correct scores 3 marks
4/5 correct scores 2 marks
2/3 correct scores 1 mark

| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| (b) | butanenitrile (1) | ALLOW butane nitrile<br>Butan(e)(1) nitrile<br>Butanitrile<br>Do not award 1-nitrile butane | (1) |

| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| (c) | • Curly arrow to show attack on C-Br carbon by lone pair of electrons on the N of ammonia and dipole C-Br (1)<br>• Curly arrow to show loss of $Br^-$ (1)<br>• Curly arrow to show loss of $H^+$ from intermediate (1) | Example of mechanism:<br>  <br>Leaving groups must be shown for M2 and M3 but penalise only once<br>Could show another molecule of ammonia or bromide ion acting as a base to remove $H^+$ | (3) |

| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| (d) | This question assesses a student's ability to show a coherent and logically structured answer with linkages and fully-sustained reasoning.<br><br>Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning.<br><br>The following table shows how the marks should be awarded for indicative content.<br><br>Number of indicative marking points seen in answer / Number of marks awarded for indicative marking points<br>6 / 4<br>5-4 / 3<br>3-2 / 2<br>1 / 1<br>0 / 0<br><br>The following table shows how the marks should be awarded for structure and lines of reasoning.<br><br>Number of marks awarded for structure and sustained lines of reasoning<br>Answer shows a coherent and logical structure with linkages and fully sustained lines of reasoning demonstrated thoughout. / 2<br>Answer is partially structured with some linkages and lines of reasoning. / 1<br>Answer has no linkages between points and is unstructured. / 0<br><br>Indicative points:<br>• (mechanism is nucleophilic) substitution<br>• (Precipitation/precipitate of) silver halide forms<br>• the time taken for the precipitate to form/rate of reaction depends on the carbon – halogen bond strength<br>• Strength/bond enthalpy of the C-Halogen bond decreases going down group 7/any correct comparison of at least two Hal-C bond strengths (because the **atomic** radius increases)<br>• The reactivity/rate of reaction of the bromoalkanes increases 1° < 2° < 3°/<br>• 1-bromobutane is 1°/2-bromobutane is 2° /2-bromo-2-methyl butane is 3° | Guidance on how the mark scheme should be applied.<br><br>The mark for indicative content should be added to the mark for lines of reasoning. For example, an answer with five indicative marking points that is partially structured with some linkages and lines of reasoning, scores 4 marks (3 marks for indicative content and 1 mark for partial structure and some linkages and lines of reasoning).<br><br>If there are no linkages between points, the same five indicative marking points would yield an overall score of 3 marks (3 marks for indicative content and no marks for linkages).<br><br>In general, it would be expected that 5 or 6 indicative points would get 2 reasoning marks, and 3 or 4 indicative points would get 1 mark for reasoning, and 0, 1 or 2 indicative points would score zero marks for reasoning.<br><br>If there is any incorrect chemistry, deduct mark(s) from the reasoning. If no reasoning mark(s) awarded, do not deduct mark(s).<br><br>Ignore hydrolysis as given in the question<br><br>Can be shown in an equation<br>Incorrect colours of ppts loses 1RP<br><br>Ignore length of bond in IP3 and IP4<br>Incorrect reason for decrease loses 1 RP. Ignore references to electronegativity.<br><br>Consideration of intermolecular forces loses 1 RP<br><br>IP5 could be scored by correct comparison of the reactivity/rate of reaction of any 2 bromoalkanes<br><br>ALLOW the production of the appropriate carbocation | (6) |