CHEMISTRY

UNIT 4(IAL)

2020 — 2025

1 – (WCH11/4(IAL)_Summer_2020_Q1) – *Rates, Equilibria And Further Organic Chemistry*

Bromine oxidises methanoic acid to carbon dioxide.

The equation for the reaction is

$$HCOOH(aq) + Br_2(aq) \rightarrow 2H^+(aq) + 2Br^-(aq) + CO_2(g)$$

Which of the following methods would **not** be suitable for measuring the progress of this reaction?

☒ **A** colorimetry

☒ **B** measuring electrical conductivity

☒ **C** quenching and titrating with acid

☒ **D** measuring the volume of gas

2 – (WCH11/4(IAL)_Summer_2020_Q2) – *Rates, Equilibria And Further Organic Chemistry*

The rate of the reaction between two compounds, **Y** and **Z**, was investigated.
The results are shown.

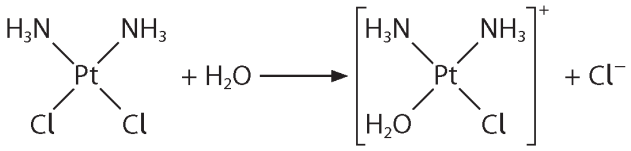
Experiment	Initial concentration of **Y** / mol dm^{-3}	Initial concentration of **Z** / mol dm^{-3}	Initial rate / mol dm^{-3} s^{-1}
1	0.64	0.24	8.00×10^{-3}
2	0.64	0.48	3.20×10^{-2}
3	0.32	0.48	3.20×10^{-2}

What are the orders of reaction with respect to **Y** and **Z**?

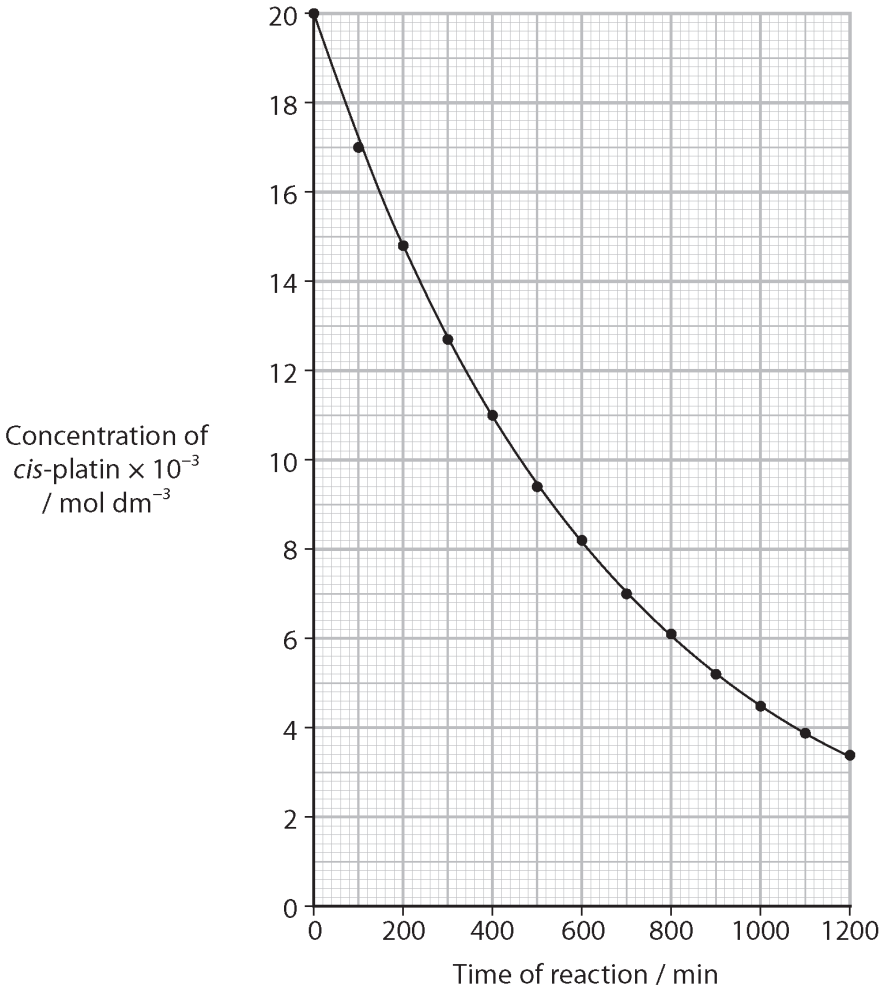
	Order with respect to **Y**	Order with respect to **Z**
☒ **A**	0	1
☒ **B**	0	2
☒ **C**	1	1
☒ **D**	1	2

3 – (WCH11/4(IAL)_Summer_2020_Q3) – *Rates, Equilibria And Further Organic Chemistry*

The inorganic anti-cancer drug *cis*-platin, $Pt(NH_3)_2Cl_2$, is hydrolysed by water to make it active. The reaction is



The hydrolysis is first order overall. The half-life can be found from a graph of the concentration of *cis*-platin against time.



The half-life of the reaction is

- ☐ **A** 430 min
- ☐ **B** 460 min
- ☐ **C** 590 min
- ☐ **D** 600 min

4 – (WCH11/4(IAL)_Summer_2020_Q4) – *Rates, Equilibria And Further Organic Chemistry*

Propanone reacts with iodine in acidic solution.

$$CH_3COCH_3(aq) + I_2(aq) \rightarrow CH_3COCH_2I(aq) + H^+(aq) + I^-(aq)$$

The rate equation for the formation of iodopropanone is found to be

$$\text{rate} = k[CH_3COCH_3(aq)][H^+(aq)]$$

(a) Which of the following is true?

(1)

- ☐ **A** the units for the rate constant are $dm^3\ mol^{-1}\ s^{-1}$
- ☐ **B** the reaction is a first order reaction overall
- ☐ **C** the units for the rate are $dm^3\ mol^{-1}\ s^{-1}$
- ☐ **D** doubling the concentrations of propanone and of iodine quadruples the rate

(b) Which of the following is **not** true?

(1)

- ☐ **A** the reaction rate increases if the temperature is raised
- ☐ **B** the rate constant increases if the temperature is raised
- ☐ **C** the addition of a small amount of sodium hydroxide decreases the reaction rate
- ☐ **D** the rate is unchanged when the hydrogen ion concentration is doubled

5 – (WCH11/4(IAL)_Summer_2020_Q5) – *Rates, Equilibria And Further Organic Chemistry*

The equation shows the hydrolysis of a bromoalkane.

$$RBr + OH^- \rightarrow ROH + Br^-$$

The rate equation is rate = k[RBr]

RBr is most likely to be

- ☐ **A** bromomethane
- ☐ **B** 2-bromopropane
- ☐ **C** 1-bromo-2-methylpropane
- ☐ **D** 2-bromo-2-methylpropane

6 – (WCH11/4(IAL)_Summer_2020_Q6) – *Rates, Equilibria And Further Organic Chemistry*

The equation for an exothermic reaction is shown.

$$Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$$

Which of these is true?

☒ **A** ΔH is positive

☒ **B** $\Delta S_{surroundings}$ is positive

☒ **C** ΔS_{system} is negative

☒ **D** ΔS_{total} is negative

7 – (WCH11/4(IAL)_Summer_2020_Q7) – *Rates, Equilibria And Further Organic Chemistry*

The equation for the equilibrium decomposition of hydrogen iodide into hydrogen and iodine can be written in two ways.

$2HI(g) \rightleftharpoons H_2(g) + I_2(g)$ Equilibrium constant = K_c

or

$HI(g) \rightleftharpoons \frac{1}{2}H_2(g) + \frac{1}{2}I_2(g)$ Equilibrium constant = K_c'

What is the expression linking the two equilibrium constants?

☒ **A** $K_c = (K_c')^2$

☒ **B** $K_c = K_c'$

☒ **C** $K_c = 2(K_c')$

☒ **D** $K_c = \sqrt{K_c'}$

8 – (WCH11/4(IAL)_Summer_2020_Q8) – *Rates, Equilibria And Further Organic Chemistry*

A buffer solution contains ethanoic acid, with a concentration of 0.10 mol dm^{-3}, and sodium ethanoate, with a concentration of 0.050 mol dm^{-3}.

K_a for ethanoic acid = 1.7×10^{-5} mol dm^{-3}

The pH of this buffer solution is

☒ **A** 2.88

☒ **B** 4.47

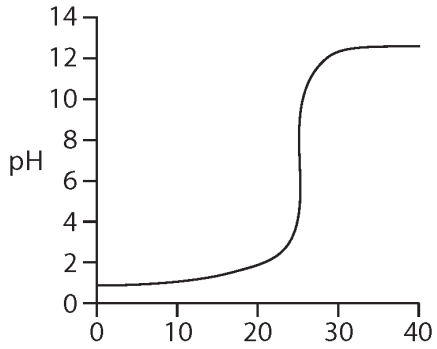
☒ **C** 4.77

☒ **D** 5.07

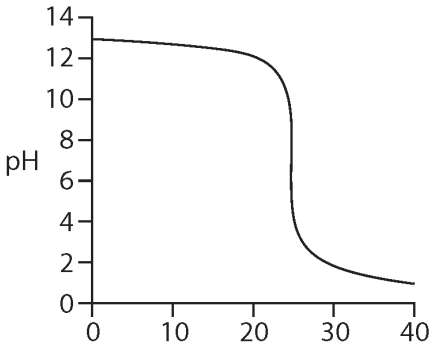
9 – (WCH11/4(IAL)_Summer_2020_Q9) – *Rates, Equilibria And Further Organic Chemistry*

The graphs show the changes in pH during a series of titrations.
Each titration involves two solutions, each of concentration 0.1 mol dm^{-3}.

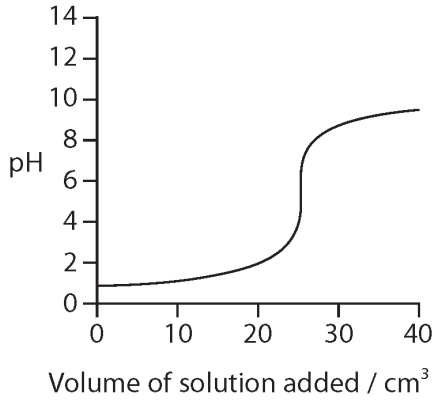
Graph **1**



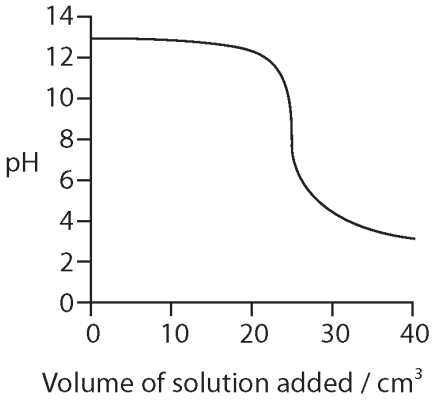
Graph **2**



Graph **3**



Graph **4**



(a) Which graph has ethanoic acid as one of the reactants?

(1)

- ☐ **A** Graph **1**
- ☐ **B** Graph **2**
- ☐ **C** Graph **3**
- ☐ **D** Graph **4**

(b) Which graph shows a solution that has an acidic pH at the end-point?

(1)

- ☒ **A** Graph **1**
- ☒ **B** Graph **2**
- ☒ **C** Graph **3**
- ☒ **D** Graph **4**

(c) Which indicator is suitable for the titration shown in Graph **3**?
Use your Data Booklet.

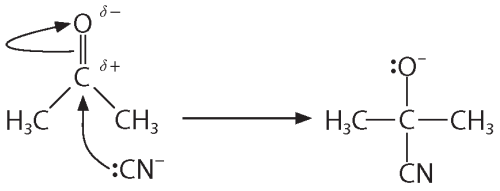
(1)

- ☒ **A** bromocresol green
- ☒ **B** bromothymol blue
- ☒ **C** phenol red
- ☒ **D** thymol blue (acid)

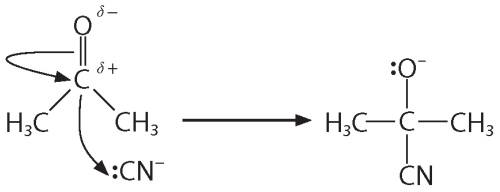
10 – (WCH11/4(IAL)_Summer_2020_Q10) – *Rates, Equilibria And Further Organic Chemistry*

Which diagram shows the first step of the mechanism for the nucleophilic addition of hydrogen cyanide to propanone in the presence of potassium cyanide?

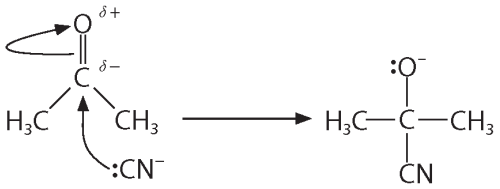
☒ **A**



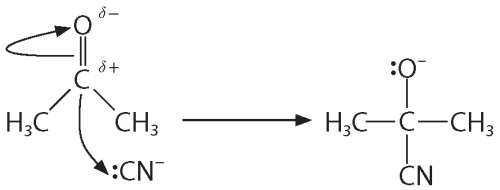
☒ **B**



☒ **C**



☒ **D**



11 – (WCH11/4(IAL)_Summer_2020_Q11) – *Rates, Equilibria And Further Organic Chemistry*

When propanone reacts with iodine in the presence of sodium hydroxide, the precipitate formed has the formula

☒ **A** CH_3I

☒ **B** CHI_3

☒ **C** CH_3COCH_2I

☒ **D** CH_3COCI_3

12 – (WCH11/4(IAL)_Summer_2020_Q12) – *Rates, Equilibria And Further Organic Chemistry*

Which of the following could **not** be formed when methylamine is added to ethanoyl chloride?

☒ **A** HCl

☒ **B** $CH_3NH_3^+Cl^-$

☒ **C** CH_3CONH_2

☒ **D** $CH_3CONHCH_3$

13 – (WCH11/4(IAL)_Summer_2020_Q13) – *Rates, Equilibria And Further Organic Chemistry*

In which of these esters is the percentage by mass of carbon 54.5 %?

☒ **A** methyl methanoate, $HCOOCH_3$

☒ **B** methyl ethanoate, CH_3COOCH_3

☒ **C** ethyl ethanoate, $CH_3COOCH_2CH_3$

☒ **D** ethyl methanoate, $HCOOCH_2CH_3$

14 – (WCH11/4(IAL)_Summer_2020_Q14) – *Rates, Equilibria And Further Organic Chemistry*

An organic compound that reacts with **both** lithium tetrahydridoaluminate(III) (lithium aluminium hydride) **and** magnesium could be

☒ **A** an aldehyde

☒ **B** a carboxylic acid

☒ **C** a ketone

☒ **D** a tertiary alcohol

15 – (WCH11/4(IAL)_Summer_2020_Q15) – *Rates, Equilibria And Further Organic Chemistry*

The following methods can be used to distinguish between pairs of organic compounds with **no** further tests.

A warm each compound with Fehling's or Benedict's solution

B warm each compound with acidified potassium dichromate(VI) solution

C add 2,4-dinitrophenylhydrazine (Brady's reagent) to each compound

D add a few drops of each compound, drop by drop, to water

(a) Which test would distinguish between 2-methylpropan-2-ol, $(CH_3)_3COH$, and butanone, $CH_3CH_2COCH_3$?

(1)

☐ **A**

☐ **B**

☐ **C**

☐ **D**

(b) Which test would distinguish between 2-methylpropan-2-ol, $(CH_3)_3COH$, and butan-1-ol, $CH_3CH_2CH_2CH_2OH$?

(1)

☐ **A**

☐ **B**

☐ **C**

☐ **D**

(c) Which test could **not** be used to distinguish between 2-methylpropan-2-ol, $(CH_3)_3COH$, and butanal, $CH_3CH_2CH_2CHO$?

(1)

☐ **A**

☐ **B**

☐ **C**

☐ **D**

16 – (WCH11/4(IAL)_Summer_2020_Q16) – *Rates, Equilibria And Further Organic Chemistry*

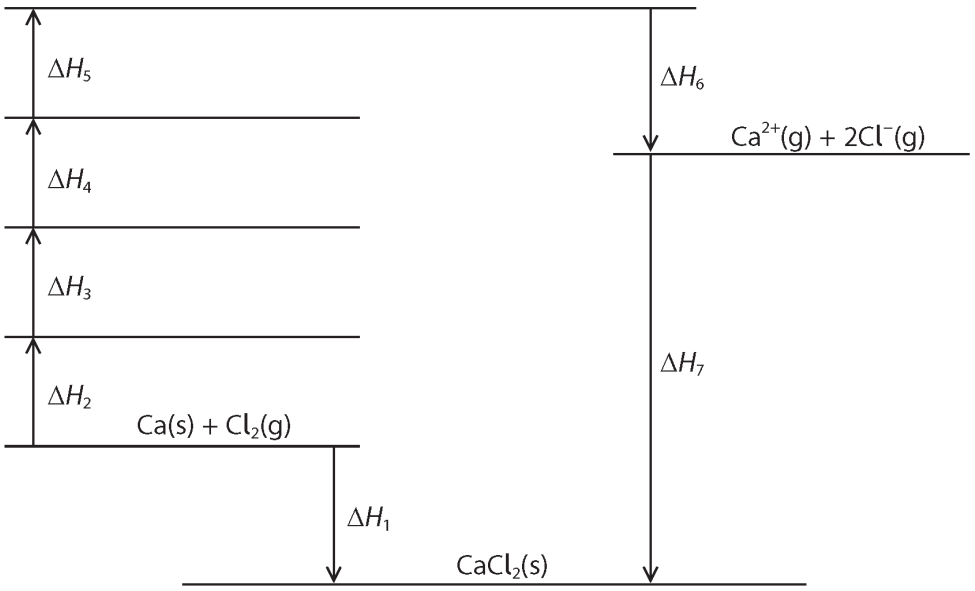
This question concerns calcium chloride, $CaCl_2$.

(a) Some energy changes related to calcium chloride are shown.

Energy change	Value / kJ mol^{-1}
Atomisation energy of calcium	+178.2
Atomisation energy of chlorine	+121.7
Electron affinity of chlorine	−348.8
First ionisation energy of calcium	+590.0
Standard enthalpy change of formation of calcium chloride	−795.8
Experimental lattice energy of calcium chloride	−2 258
Second ionisation energy of calcium	To be calculated

(i) Complete the Born-Haber cycle by writing appropriate chemical formulae on the horizontal lines. Include state symbols and relevant electrons.

(4)



(ii) Calculate the second ionisation energy of calcium using the cycle and the values given in the table. Include a sign and units with your value.

(3)

(b) The theoretical lattice energy of formation of $CaCl_2$ is $-2\,223$ kJ mol^{-1}.
Explain why the experimental lattice energy of $CaCl_2$ is more exothermic than the theoretical value.

(3)

(c) The table shows the theoretical lattice energies of some chlorides of Group 2.

Group 2 metal chloride	magnesium chloride	calcium chloride	strontium chloride	barium chloride
Lattice energy / kJ mol^{-1}	−2326	−2223	−2127	−2033

Explain the trend in **theoretical** lattice energies on descending Group 2.

(3)

(d) Calculate the enthalpy change of solution of calcium chloride, $CaCl_2$.

Data

$\Delta_{hyd}H^{\ominus}(Ca^{2+}) = -1\,650$ kJ mol^{-1} $\Delta_{hyd}H^{\ominus}(Cl^{-}) = -364$ kJ mol^{-1}

Experimental lattice energy ($CaCl_2$) = −2 258 kJ mol^{-1}

(2)

17 – (WCH11/4(IAL)_Summer_2020_Q17) – *Rates, Equilibria And Further Organic Chemistry*

This question concerns six isomers each with the molecular formula $C_5H_{10}O_2$.

(a) Isomers **A**, **B**, **C** and **D** are structural isomers that all react with aqueous sodium carbonate to produce carbon dioxide.

Isomer **A** is a straight-chain compound.

Isomer **B** has only two peaks in its high resolution proton NMR spectrum, both of which are singlets.

Isomer **C** contains a chiral centre but isomer **D** does not.

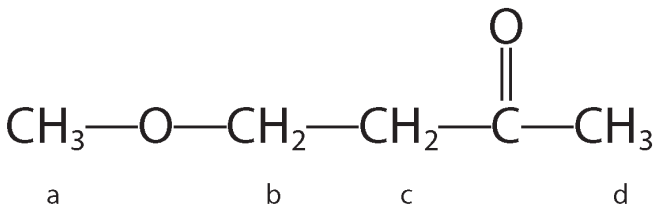
Give the structures of these **four** isomers.

(4)

A	**B**

C	**D**

(b) (i) Isomer **E** contains an ether functional group (R-O-R) and a ketone functional group. The **low** resolution proton NMR spectrum of isomer **E** has four peaks. The displayed formula of isomer **E** is



The four hydrogen environments responsible for the four peaks are labelled. Complete the table of information regarding these peaks including the splitting pattern in the **high** resolution spectrum.

(3)

Peak	a	b	c	d
Relative peak area	3			
Chemical shift range, δ / ppm	2.9 – 4.2			
Splitting	singlet			

(ii) State the number of peaks in the carbon-13 (^{13}C) NMR spectrum of **E**.

(1)

.....

(c) Isomer **F** is a neutral compound that smells of pears.

It can be formed by the reaction between compounds **V** and **W** in the presence of concentrated sulfuric acid.

Compound **V** has an absorption in its infrared spectrum at 1720 cm^{-1} and a broad absorption around 3050 cm^{-1}.

Compound **W** can be formed directly from propanal.

(i) Identify, by name or formula, compounds **V**, **W** and **F**.

Justify your answer by using **all** the available information.

(4)

(ii) State the conditions required and the reagent needed to form compound **W** from propanal.

(1)

.....

(iii) State the role of sulfuric acid in the formation of **F**.

(1)

.....

(d) State which one of the isomers **A**, **E** and **F** has the highest boiling temperature. Justify your answer.

(3)

18 – (WCH11/4(IAL)_Summer_2020_Q18) – *Rates, Equilibria And Further Organic Chemistry*

This question concerns acidic solutions.

(a) (i) A solution of hydrochloric acid has a pH of 1.125.

Calculate the concentration of hydrogen ions and of hydroxide ions, in mol dm^{-3}, in this solution.

[$K_w = 1.00 \times 10^{-14}$ mol^2 dm^{-6}]

(2)

(ii) Calculate the volume of water which must be added to 25.0 cm^3 of this solution to increase the pH from 1.125 to 1.500, giving your answer to an appropriate number of significant figures.

(4)

(b) Phosphoric(V) acid, H_3PO_4, is a weak acid, which dissolves in water, giving the equilibrium

Equation 1 $H_3PO_4(aq) + H_2O(l) \rightleftharpoons H_2PO_4^-(aq) + H_3O^+(aq)$

The $H_2PO_4^-$ ion formed when phosphoric(V) acid is added to water can dissociate further into HPO_4^{2-}.

Equation 2 $H_2PO_4^-(aq) + H_2O(l) \rightleftharpoons HPO_4^{2-}(aq) + H_3O^+(aq)$

....

(i) Identify the acids and bases in the spaces below Equation 2, linking the acid-base conjugate pairs.

(2)

(ii) Explain why very little dissociation of the $H_2PO_4^-$ ion occurs in solutions of phosphoric(V) acid.

(2)

(c) (i) Using Equation 1, write an expression for the acid dissociation constant, K_{a1}, for phosphoric(V) acid, H_3PO_4.

(1)

(ii) A 0.500 mol dm^{-3} solution of phosphoric(V) acid has a pH of 1.20. Calculate the value of K_{a1}, stating its units.

Assume that there is no further dissociation of the $H_2PO_4^-$ ion.

(4)

(d) Phosphate buffer solutions containing hydrogenphosphate ions, HPO_4^{2-}, and dihydrogenphosphate ions, $H_2PO_4^-$, are commonly used in biological research.

Explain, using a relevant ionic equation, how a solution containing these ions can act as a buffer when a small amount of **alkali** is added.

(3)

ANSWERS

1 – (WCH11/4(IAL)_Summer_2020_Q1) – *Rates, Equilibria And Further Organic Chemistry*

C

2 – (WCH11/4(IAL)_Summer_2020_Q2) – *Rates, Equilibria And Further Organic Chemistry*

B

3 – (WCH11/4(IAL)_Summer_2020_Q3) – *Rates, Equilibria And Further Organic Chemistry*

B

4 – (WCH11/4(IAL)_Summer_2020_Q4) – *Rates, Equilibria And Further Organic Chemistry*

Question Number	Answer	Mark
(a)	**The only correct answer is A** (the units for the rate constant are $dm^3\ mol^{-1}\ s^{-1}$) ***B*** *is incorrect because the reaction is second order overall* ***C*** *is not correct because the units of rate are always mol* $dm^{-3}\ s^{-1}$ ***D*** *is not correct because the rate would double as iodine is zero order*	(1)

Question Number	Answer	Mark
(b)	**The only correct answer is D** (the rate is unchanged when the hydrogen ion concentration is doubled) ***A*** *is incorrect because the rate of reaction does increase with temperature* ***B*** *is incorrect because the rate constant depends on the temperature and increases as temperature rises* ***C*** *is not correct because sodium hydroxide would neutralise some of the* $[H^+]$ *catalyst so change rate*	(1)

5 – (WCH11/4(IAL)_Summer_2020_Q5) – *Rates, Equilibria And Further Organic Chemistry*

D

6 – (WCH11/4(IAL)_Summer_2020_Q6) – *Rates, Equilibria And Further Organic Chemistry*

B

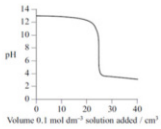
7 – (WCH11/4(IAL)_Summer_2020_Q7) – *Rates, Equilibria And Further Organic Chemistry*

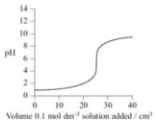
A

8 – (WCH11/4(IAL)_Summer_2020_Q8) – *Rates, Equilibria And Further Organic Chemistry*

B

9 – (WCH11/4(IAL)_Summer_2020_Q9) – *Rates, Equilibria And Further Organic Chemistry*

Question Number	Answer	Mark
(a)	**The only correct answer is D**  *A is incorrect because, if the graph starts or finishes at a pH of about 1, a strong acid is present* *B is incorrect because, if the graph starts or finishes at a pH of about 1, a strong acid is present* *C is incorrect because, if the graph starts or finishes at a pH of about 1, a strong acid is present*	(1)

Question Number	Answer	Mark
(b)	**The only correct answer is C**  *A is incorrect because the mid-point of the vertical portion of the graph is at pH = 7* *B is incorrect because the mid-point of the vertical portion of the graph is at pH = 7* *D is incorrect because the mid-point of the vertical portion of the graph is at pH > 7*	(1)

Question Number	Answer	Mark
(c)	**The only correct answer is A** *B is incorrect because the range of colour change for bromothymol blue (6.0 – 7.6) is not within the vertical portion of the graph* *C is incorrect because the range of colour change for phenol red (6.8 – 8.4) is not within the vertical portion of the graph* *D is incorrect because the range of colour change for thymol blue (acid) (1.2 – 2.8) is not within the vertical portion of the graph*	(1)

10 – (WCH11/4(IAL)_Summer_2020_Q10) – *Rates, Equilibria And Further Organic Chemistry*

A

11 – (WCH11/4(IAL)_Summer_2020_Q11) – *Rates, Equilibria And Further Organic Chemistry*

B

12 – (WCH11/4(IAL)_Summer_2020_Q12) – *Rates, Equilibria And Further Organic Chemistry*

C

13 – (WCH11/4(IAL)_Summer_2020_Q13) – *Rates, Equilibria And Further Organic Chemistry*

C

14 – (WCH11/4(IAL)_Summer_2020_Q14) – *Rates, Equilibria And Further Organic Chemistry*

B

15 – (WCH11/4(IAL)_Summer_2020_Q15) – *Rates, Equilibria And Further Organic Chemistry*

Question Number	Answer	Mark
(a)	**The only correct answer is C** (add 2,4-dinitrophenylhydrazine (Brady's reagent) to each compound) ***A** is incorrect because neither would react* ***B** is incorrect because neither would react* ***D** is incorrect because neither would react*	(1)

Question Number	Answer	Mark
(b)	**The only correct answer is B** (warm each compound with acidified potassium dichromate(VI) solution) ***A** is incorrect because neither would react* ***C** is incorrect because neither would react* ***D** is incorrect because neither would react*	(1)

Question Number	Answer	Mark
(c)	**The only correct answer is D** (add a few drops of each compound, drop by drop, to water) ***A** is incorrect because as butanal would react but 2-methylpropan-2-ol would not* ***B** is incorrect because as butanal would react but 2-methylpropan-2-ol would not* ***C** is incorrect because as butanal would react but 2-methylpropan-2-ol would not*	(1)

16 – (WCH11/4(IAL)_Summer_2020_Q16) – *Rates, Equilibria And Further Organic Chemistry*

Question Number	Answer	Additional guidance	Mark
	• Top line **(1)** • Bottom line **(1)** • Middle 2 lines **(2)**	Penalise missing or incorrect state symbol once only Penalise lack of electrons or too few electrons once only Penalise the writing of the change for each step e.g. Ca(s) → Ca(g) once only. Assume that the other substance is unchanged $Ca^{2+}(g) + 2Cl(g) + 2e^{(-)}$ Either $Ca(s) + 2Cl(g)$ or $Ca(g) + Cl_2(g)$ any two of $Ca^{+}(g) + 2Cl(g) + e^{(-)}$ or $Ca(g) + 2Cl(g)$ or $Ca^{+}(g) + Cl_2(g) + e^{(-)}$ or $Ca^{2+}(g) + Cl_2(g) + 2e^{(-)}$ Allow TE from one line to the next, so penalising any error once only.	**(4)**

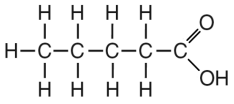
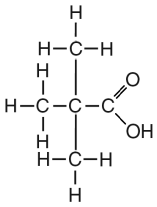
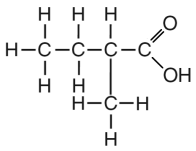
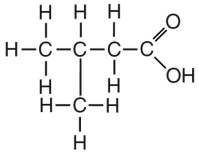
Question Number	Answer	Additional guidance	Mark
(a)(ii)	• An equation linking enthalpy changes with correct signs and / or values **(1)** • Multiplies atomisation of chlorine OR electron affinity of chlorine by 2 **(1)** • Calculates final value of second ionisation energy of calcium with sign **(1)**	Example of calculation: $\Delta H_1 = \Delta H_2 + \Delta H_3 + \Delta H_4 + \Delta H_5 + \Delta H_6 + \Delta H_7$ OR $\Delta H_6 + \Delta H_7 = \Delta H_1 - \Delta H_2 - \Delta H_3 - \Delta H_4 - \Delta H_5$ OR $\Delta H_5 = - \Delta H_4 - \Delta H_3 - \Delta H_2 + \Delta H_1 - \Delta H_7 - \Delta H_6$ OR $\Delta H_5 = - 590.0 - 178.2 - ((2 \text{ x}) 121.7) + -795.8 - - 2258 - ((2 \text{ x}) - 348.8)$ Similar numerical expressions of the other equations also score 2 x 121.7 / 243.4 / 243 OR 2 x – 348.8 / – 697.6 / – 698 (+) 1148.2 / (+) 1148 / (+) 1150 (kJ mol^{-1}) ALLOW TE on all stages of calculation for max 2. Correct answer with no working scores (3) Ignore SF except 1 SF Common incorrect answers include: – 1148.2 / – 1148 / – 1150 (kJ mol^{-1}) scores (2) (+)799.4 / (+)799 / (+)780 (kJ mol^{-1}) (1 x 348.8) scores (2) (+)1269.9 / (+)1270 (kJ mol^{-1}) (1 x 121.7) scores (2) (+)921.1 / (+)921 / (+) 920 (kJ mol^{-1}) (1 x 348.8 and 121.7) scores (1) (+)2512.7 (Changing sign of $\Delta H_6 + \Delta H_7$ and no 2 x) scores (0)	**(3)**

Question Number	Answer	Additional guidance	Mark
(b)	An explanation that makes reference to the following points: **EITHER** • Bonding is partially covalent / not purely ionic / has covalent character **(1)** • Ca^{2+} ion is small (and highly charged) **(1)** • Leading to polarisation / distortion in the electron cloud of the chloride / Cl^- (ion) / anion **(1)** **OR** • Bonding is almost purely ionic / slightly covalent **(1)** • Ca^{2+} is not sufficiently small (and highly charged) **(1)** • To polarise the chloride / Cl^- (ion) very much / to distort the electron cloud of the chloride / Cl^- (ion) **(1)**	Penalise the use of calcium and / or chlorine (atom) once only Ignore descriptions of possible macroscopic features of covalent character such as structures etc. Allow calcium ion is small and highly charged / has a high charge density Do not award chlorine Do not award distortion by calcium / calcium atom Allow virtually 100% ionic Do not award purely ionic / 100 % ionic calcium ion is not sufficiently small and highly charged / has too small a charge density Do not award calcium / calcium atom is not sufficiently small / charged Allow chloride (ion) is not very polarised / is not very polarisable Do not award chlorine Do not award chloride is not polarised / polarisable	**(3)**

Question Number	Answer	Additional guidance	Mark
(c)	An explanation that makes reference to the following points: • (on descending the group) lattice enthalpy becomes less exothermic **(1)** • as the radius of metal ion / M^{2+} ion / cation increases (and charge on ions remains the same / 2+) **(1)** • (down group) weaker forces of **attraction** between **ions** **(1)**	Penalise mention **specifically** of atoms instead of ions once only Penalise mention **specifically** of molecules once only Award reverse arguments if clearly referring to ascending the group Ignore discussion of polarising power Allow less negative / less energy is released Ignore increases / decreases Allow "size" instead of "radius" Ignore atomic radius increases Allow correct formulae of cations Do not award just "charge density decreases" without explanation Allow less attraction to chloride ion Do not award just "weaker bonds" or "weaker bonding"	**(3)**

Question Number	Answer	Additional guidance	Mark
(d)	• An expression linking enthalpy of solution, lattice enthalpy and hydration enthalpies **(1)** • Value of $\Delta_{sol}H$ **(1)**	Example of calculation $\Delta_{sol}H = -\Delta_{latt}H + (\Sigma)\Delta_{hyd}H$ OR $\Delta_{sol}H = -(-2258) + (-1650) + (2 \times -364)$ -120 (kJ mol^{-1}) Correct answer with no working scores (2) (+)120 / (+)244 / -4636 (kJ mol^{-1}) scores (1)	**(2)**

17 – (WCH11/4(IAL)_Summer_2020_Q17) – *Rates, Equilibria And Further Organic Chemistry*

Question Number	Answer	Additional guidance	Mark
(a)	• Structure A **(1)** • Structure B **(1)** • Structure C **(1)** • Structure D **(1)**	A:  B:  C:  D:  Allow condensed or skeletal formulae If Structure B has not been scored allow this structure as a correct answer for Structure D Penalise OH−C connectivity once only to horizontal bonds Ignore connectivity on vertical bonds to OH and all bonds to CH_3 groups. Penalise incorrect names also given once only	**(4)**

Question Number	Answer	Additional guidance	Mark
(b)(i)	• 3, 4 or 5 correct boxes **(1)** • 6, 7 or 8 correct boxes **(2)** • Nine correct boxes **(3)**	b: 2 / 2.7 – 4.2 / triplet c: 2 / 1.5 – 2.9 / triplet d: 3 / 1.5 – 2.9 / singlet Allow a value or range within the range Allow triple / single 3lines / 1 line	**(3)**

Question Number	Answer	Additional guidance	Mark
(b)(ii)	• Five / 5 (peaks)		**(1)**

Question Number	Answer	Additional guidance	Mark
(c)(i)	• Identifies isomer **F** **(1)** • Identifies compound **V** and compound **W** **(1)** • Two points of justification for identification of isomer **F**, compound **V** and compound **W** **(2)**	Penalise use of C_3H_7 for formulae once only **F** is propyl ethanoate / $CH_3COOCH_2CH_2CH_3$ Allow TE on incorrect alcohol or carboxylic acid for V and W If name and formula is given both must be correct Compound **V** is ethanoic acid / CH_3COOH and Compound **W** is propan-1-ol / $CH_3CH_2CH_2OH$ Ignore just 'propanol' Any two from: Compound **V** is a carboxylic acid justified by infra-red Award for correct identification of the bond responsible for either peak? Compound **W** is propan-1-ol / an alcohol / propanol justified by reduction of propanal Allow propanol here but not in M2 Compound **V** or **W** justified by reaction with the other to form an ester Compound **F** is an ester justified by smell / neutral compound	**(4)**

Question Number	Answer	Additional guidance	Mark
(c)(ii)	• (Lithium tetrahydridoalumate(III) / lithium aluminium hydride) / $LiAlH_4$ **AND** in dry ether / diethyl ether / ethoxyethane (solvent)	ALLOW Lithal ALLOW Sodium tetrahydridoborate / sodium borohydride AND Water / ethanol solvent	**(1)**

Question Number	Answer	Additional guidance	Mark
(c)(iii)	• Catalyst	Ignore mention of acid / homogeneous / proton donor Ignore additional words Do not award just 'proton donor' or donates hydrogen ions	**(1)**

Question Number	Answer	Additional guidance	Mark
(d)	An explanation that makes reference to the following points: • Isomer A (has the highest boiling temperature) **(1)** • (Isomer A has the) **only** molecules held together by hydrogen bonding / Isomer A forms hydrogen bonds but E and F do not **(1)** • Hydrogen bonds are the strongest intermolecular forces **(1)**	In general ignore reference to other intermolecular forces (but see below) Allow it forms hydrogen bonds Ignore it forms hydrogen bonds with other compounds/substances Ignore comments about straight chain so stronger London forces Allow hydrogen bonding is stronger than London forces and/or permanent dipoles Allow just 'forms strong hydrogen bonds'	**(3)**

18 – (WCH11/4(IAL)_Summer_2020_Q18) – *Rates, Equilibria And Further Organic Chemistry*

Question Number	Answer	Additional guidance	Mark
(a)(i)	• Calculation of hydrogen ion concentration **(1)** • Calculation of hydroxide ion concentration **(1)**	Example of calculation ($[H^+] = 10^{-pH}$) $[H^+] = 0.074989 / 0.075 / 7.4989 \times 10^{-2}$ (mol dm^{-3}) Do not award just $[H^+] = 10^{-1.125}$ ($[OH^-] = 1.0 \times 10^{-14} \div 0.074989$) $[OH^-] = 1.3335 \times 10^{-13}$ (mol dm^{-3}) Allow = $1 \times 10^{-12.875}$ Allow 1 mark for correct unidentified concentrations whatever order they are given Ignore SF except 1 SF	**(2)**

Question Number	Answer	Additional guidance	Mark
(a)(ii)	• Calculation of moles of H^+ in original solution **(1)** • Calculation of concentration of H^+ in new solution **(1)** • Calculation of volume of new solution **(1)** • Calculation of volume of water needed to add giving answer to 2 or 3 SF **(1)** OR • Calculation of change in pH **(1)** • Concentration of change of concentration of H^+ **(1)** • Calculation of volume of new solution **(1)** • Calculation of volume of water needed to add giving answer to 2 or 3 SF **(1)**	Example of calculation = 0.074989 x 25 ÷ 1000 = 0.0018747 / 1.8747 x 10^{-3} (mol) $[H^+] = 10^{-1.5}$ / 0.031623 / 3.1623 x 10^{-2} (mol dm^{-3}) 0.0018747 ÷ 0.031623 = 0.059284 (dm^3) 59.284 – 25.000 = 34.29284 (cm^3) = 34.3 / 34 (cm^3) = 1.5 – 1.125 = 0.375 $[H^+] = 10^{-0.375}$ / 0.42170 / 4.2170 x 10^{-1} (mol dm^{-3}) = 25 ÷ 0.42170 = 59.284 (cm^3) 59.284 – 25.000 = 34.29284 (cm^3) = 34.3 / 34 (cm^3) Allow 0.034 / 0.0343 dm^3 Allow TE throughout including from (a)(i) Correct answer with no working scores (4) Ignore SF except 1 SF until final answer	**(4)**

Question Number	Answer	Additional guidance	Mark
(b)(i)	• Any two correct acid or base **(1)** • All four correct acid and base plus indication of pairings **(1)**	e.g. $H_2PO_4^-(aq) + H_2O(l) \rightleftharpoons HPO_4^{2-}(aq) + H_3O^+(aq)$ Acid ..... Base ..... Conjugate Base ..... Conjugate Acid ..... OR acid ..... base ..... base ..... acid ..... linked in some way to show pairs (eg as shown) scores (2) Just acid ..... base ..... base ..... acid ..... scores (1)	**(2)**

Question Number	Answer	Additional guidance	Mark
(b)(ii)	An explanation that makes reference to the following points: • oxonium / H_3O^+ ion produced in first dissociation **(1)** • (prevents further dissociation by) pushing second equilibrium to the left. **(1)**	Allow hydronium / hydroxonium ion / H^+	**(2)**

Question Number	Answer	Additional guidance	Mark
(c)(i)	• Correct expression for K_{a1}	$K_{a1} = \frac{[H_2PO_4^-((aq))][H_3O^+((aq))]}{[H_3PO_4((aq))]}$ Allow use of H^+ instead of H_3O^+ Do not award the charge outside of the square bracket	**(1)**

Question Number	Answer	Additional guidance	Mark
(c)(ii)	• Calculate hydrogen ion concentration **(1)** • States $[H_2PO_4^-((aq))] = [H_3O^+((aq))]$ or shown in the expression for K_{a1} **(1)** • Calculates K_{a1} **(1)** • Units **(1)**	Example of calculation: $= 10^{-pH}$ / $10^{-1.2}$ / 0.063096 / 6.3096 x 10^{-2} / 0.0631 / 6.31 x 10^{-2} Do not award 0.0630 but TE can be awarded for the remaining marks Allow TE for an incorrect expression for K_{a1} $K_{a1} = \frac{[H_3O^+((aq))]^2}{[H_3PO_4((aq))]}$ $K_{a1} = \frac{(0.063096)^2}{0.500 - 0.063096} = \frac{0.0039811}{0.43690}$ = 0.0091121 / 9.1121 x 10^{-3} / 0.00911 / 9.11 x 10^{-3} ALLOW Use of assumption $[H_3PO_4(aq)] = 0.500$ = 0.0079621 / 7.9621 x 10^{-3} / 0.00796 / 7.96 x 10^{-3} Correct value with no working scores (3) mol dm^{-3} Correct answer with no working and correct units scores (4) Ignore SF except 1 SF but allow 0.5 for concentration	**(4)**

Question Number	Answer	Additional guidance	Mark
(d)	An explanation that makes reference to the following points: • The mixture contains a (large) reservoir / high concentration of **both** phosphate ions / of hydrogen phosphate and dihydrogen phosphate ions / of $H_2PO_4^-$ and HPO_4^{2-} **(1)** **Either** • Added OH^- combines with H^+ to form water / $H^+ + OH^- \rightarrow H_2O$ **AND** Dihydrogen phosphate ion / $H_2PO_4^-$ dissociates to form more H^+ / $H_2PO_4^- \rightleftharpoons HPO_4^{2-} + H^+$ **Or** Added OH^- reacts with dihydrogen phosphate ion (to form water) / $OH^- + H_2PO_4^- \rightleftharpoons HPO_4^{2-} + H_2O$ **(1)** • (pH changes very little because added OH^- is removed) and change in concentration of $H_2PO_4^-$ **and** HPO_4^{2-} is small / ratio [salt]/[acid] hardly changes **(1)**	Allow large amount / abundance For this mark to be scored at least one ionic equation is required If the equilibrium is given allow 'added OH^- causes the equilibrium to move to the right' Allow pH is unchanged Allow ratio changes a little / changes slightly Ignore there is no change in concentrations / the ratio is unchanged	**(3)**