PEARSON EDEXCEL A-LEVEL CHEMISTRY · 9CH0

CHEMISTRY



MARK SCHEME

TOPIC 8: ENERGETICS I

SCORE	PERCENTAGE
/96	%

STEMUP

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Mark Scheme

Q1.

Question Number	Acceptable Answers	Additional Guidance	Mark
(a)	• 1.60 **(1)** • (+) 42.5 **(1)**	Do not award MP1 for "1.6" (must be to 2 D.P.) Do not award MP2 for "42.50" (must be to 1 D.P.) Penalise D.P. error once only	**(2)**

Question Number	Acceptable Answers	Additional Guidance	Mark
(b)	$CH_3OH(l) + 1.5O_2(g) \rightarrow CO_2(g) + 2H_2O(l)$ • Balanced equation **(1)** • State symbols all correct **(1)**	Do not award multiples (enthalpy change is for the complete combustion of one mole) for MP1 MP2 depends on the award of MP1 or correct species	**(2)**

Question Number	Acceptable Answers	Additional Guidance	Mark
(c)	• Calculation of energy change **(1)** • Calculation of moles of CH_3OH **(1)** • Calculation of energy ÷ moles CH_3OH **(1)** • ΔH final answer in kJ mol^{-1} **and** negative sign included **and** ΔH final answer to 2 or 3 S.F. **(1)**	Example of calculation (= $mc\Delta T$ = 150 x 4.18 x 42.5 =) 26647.5 (J) Moles CH_3OH = 1.60/32 (= 0.05(00)) $\frac{26647.5}{0.05(00)}$ = 532950 (J mol^{-1}) Ignore any signs at this stage −533 (kJ mol^{-1}) **Or** −530 (kJ mol^{-1}) Correct answer with no working gains full marks Penalise incorrect units for MP4 only Allow TE at each stage Allow correct rounding to 2SF or more at each stage	**(4)**

Question Number	Acceptable Answers	Additional Guidance	Mark
(d)(i)	(±)0.7 (%)	Allow from 1 SF up to calculator value correctly rounded where (% uncertainty =) (±) $\frac{1}{150}$ x 100 = 0.66666...7 (%) . Allow 0.6 or $\frac{2}{3}$ Do not award 0.66/0.6	(1)

Question Number	Acceptable Answers	Additional Guidance	Mark
(d)(ii)	An answer that makes reference to the following points: • Calculation of the % uncertainty using the 25 cm^3 measuring cylinder **(1)** **Then any two from:** • % uncertainty with use of 25 cm^3 measuring cylinder is greater **(1)** • Repeated use of the small measuring cylinder will lead to greater transfer losses **(1)** • Repeated use will take more time **(1)**	Needs to show combined error in using the 25 cm^3 six times is greater than using 250 cm^3 measuring cylinder once only Award MP1 EITHER if multiplies errors: 100 x (0.2 /25) x 6 = 4.8% OR If adds errors 100 x (1.2 /150) = 0.8% Do not award (0.2 / 25) x 100 = 0.8 % Do not award 'easier' to use larger measuring cylinder	(3)

Question Number	Acceptable Answers	Additional Guidance	Mark
(d)(iii)	An answer that makes reference to any **three** of the following points: • heat/energy loss (to the surroundings) **(1)** • evaporation of methanol / water from the calorimeter **(1)** • incomplete combustion (of methanol) **(1)** • (specific) heat capacity of the calorimeter/apparatus has been ignored **(1)**	Ignore experiment carried out under non-standard conditions Ignore just 'no lid' Allow calorimeter has not been calibrated	**(3)**

Question Number	Acceptable Answers	Additional Guidance	Mark
(e)	An explanation that makes reference to the following points: • The second value will be less exothermic / less negative **(1)** • Some energy will be used to boil the water/boiling water is endothermic Water can only be heated to 100°C/ Temperature rise (measured) can only be (a maximum) of 40°C Greater heat losses in the 60°C to 100°C range **(1)**	 Allow 'more positive' or 'smaller in magnitude' Do not accept 'greater' or 'smaller' for 'less negative' Do not award **just** "the water boils" Mark points M1 and M2 independently	**(2)**

Question Number	Acceptable Answers	Additional Guidance	Mark
(f)	An explanation that makes reference to the following points: Either • student 2's value will be similar / the same **(1)** • (As) both the energy change **and** moles/mass (of methanol) burned will be higher/ Ratio of energy change to moles/mass (of methanol) burned will be the same/ The energy change is proportional to the moles/mass (of methanol) burned **(1)** Or • student 2's value will be less negative/ less exothermic **(1)** • greater heat loss because higher temperature/heated for longer **(1)**	Allow 'temperature change' for 'energy change' Allow 'more positive' or 'smaller in magnitude' or 'smaller' for 'less negative' Mark points MP1 and MP2 independently within each route	**(2)**

Question Number	Acceptable Answers	Additional Guidance	Mark
(g)	An answer that makes reference to the following points: • (Calculated) value of moles (of methanol) burned will be less / too small **(1)** • The calculated value will be more exothermic / more negative **(1)**	Allow **both** marks for a calculation using M_r of 46.0 (instead of 32.0), giving a final ΔH value (approx.) of −766 (kJ mol^{-1}) Allow 'increase' or 'greater' for 'more negative' MP2 depends on MP1	**(2)**

Q2.

Question Number	Answer	Additional Guidance	Mark
(i)	• sum of bonds broken (1) • and sum of bonds made (1) • answer **and** with negative sign (1)	Example of calculation bonds broken = (6 x 198) + (10 x 243) = 3618 (kJ mol^{-1}) bonds made = (20 x 326) = (−)6520 (kJ mol^{-1}) enthalpy change = Bonds broken – bonds made = (3618 − 6520) =−2902 (kJ mol^{-1}) Correct answer with no working scores (3) TE on bonds broken and made	(3)

Question Number	Answer	Additional Guidance	Mark
(ii)	• bond breaking requires energy or by convention bond enthalpies refer to dissociation and so are endothermic	ALLOW bond breaking is endothermic ALLOW bond making is exothermic Ignore just 'bonds are broken' / 'it is endothermic'	(1)

Q3.

Question Number	Answer	Additional Guidance	Mark
	• calculation of energy needed to break bonds **(1)** • calculation of energy released when bonds are made **(1)** • calculation of mean bond enthalpy of C—O **(1)**	Example of calculation Energy to break bonds: (C—C) + (C—H) + (C—O) = 347 + 413 + (C—O) = (C—O) + 760 (kJ) Energy released in forming bonds: (C=C) + (O—H) = 612 + 464 = (−)1076 (kJ) (C—O) + 760 − 1076 = 42 (C—O) = (+)358 (kJ mol^{-1}) TE on M1 and M2 If all bonds broken: Energy to break bonds = (C—O) + 4049 (kJ) Energy released in forming bonds = (−)4365 (kJ) Ignore units Correct answer with no working scores (3) Allow correct working in M1 and M2 if answers not evaluated	**(3)**

Q4.

Question Number	Answer	Additional Guidance	Mark
(i)	An answer that makes reference to the following points: • identification and correction of the first error **(1)** • identification and correction of the second error **(1)**	Allow corrections to be made on the diagram Error 1 – arrow for enthalpy change of formation should go down/be reversed Error 2 – the word 'half ' should be deleted from the enthalpy change of atomisation of hydrogen	**(2)**

Question Number	Answer	Additional Guidance	Mark
(ii)	• calculation of first electron affinity of hydrogen	Example of calculation 1st EA= –(218+496+107)–56 +804 = –73 (kJ mol^{-1}) Allow a TE 1st EA = +39(kJ mol^{-1}) if the first arrow reversed direction is not identified	(1)

Q5.

Question Number	Answer	Additional Guidance	Mark
	• calculation of moles used **(1)** • calculation of energy for that number of moles **(1)** • calculation of temperature change **and** gives answer to 2 SF (because a school thermometer cannot measure to 3 SF) **(1)**	Example of calculation moles used = 25.0 x 1.00/1000 = 0.0250 energy released = 0.025 x 53.4 = 1.335 (kJ) / 1335 (J) TE on moles used Ignore sign temperature change = 1335/(50.0 x 4.18) = 6.3876 = 6.4 (°C / K) TE on moles and energy Allow final answer to 3 SF 6.39 (°C / K) Ignore units Correct answer with no working scores (3)	(3)

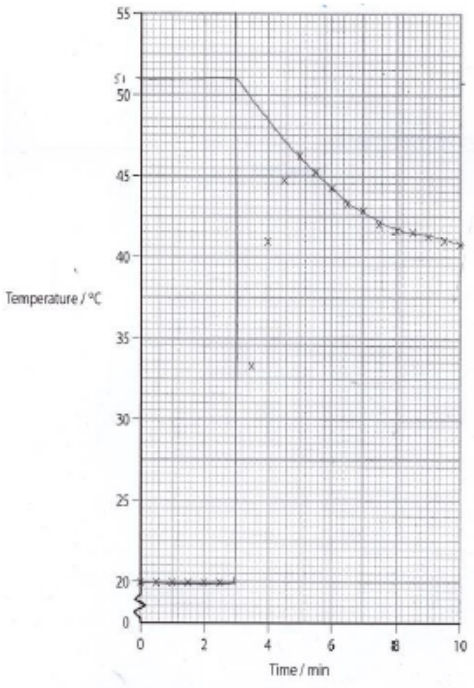
Q6.

Question Number	Answer	Additional Guidance	Mark
(i)	• mass **and** temperature fall correct	Mass of $NaHCO_3$ used / g: 5.62 Temperature fall / °C: (–)6.6	(1)

Question Number	Answer		Additional Guidance	Mark
(ii)	• calculation of amount of $NaHCO_3$ **and** calculation of amount of hydrochloric acid	(1)	Example of calculation amount $NaHCO_3$ = 5.62 / (23 + 1 + 12 + (3 x 16)) = 0.0669 (mol) TE on mass of $NaHCO_3$ in (a)(i) **and** amount HCl = 50 x 2.00 / 1000 = 0.10 (mol) Ignore SF including 1SF Allow mol ratio = 1 : 1 so HCl is in excess Allow just more moles of HCl used Allow 0.10 > 0.0669 (mol) Allow HCl is in excess by 0.033 (mol)	(2)
	• 0.0669 mol $NaHCO_3$ needs 0.0699 mol HCl for reaction so HCl is in excess	(1)		

Question Number	Answer		Additional Guidance	Mark
(iii)	• calculation of heat absorbed	(1)	Example of calculation heat absorbed = 50.0 x 4.18 x 6.6 = 1379.4 (J) / 1.3794 (kJ) Ignore sign	(3)
	• calculation of enthalpy change	(1)	enthalpy change = 1379.4 / 0.0669 = 20619 (J mol^{-1}) **or** = 1.3794 / 0.0669 = 20.619 (kJ mol^{-1}) TE on heat absorbed and amount $NaHCO_3$ in (a)(ii)	
	• positive sign **and** units	(1)	Final answer +20.6(19) kJ mol^{-1} **or** +20619 J mol^{-1} TE on enthalpy change Allow +19.7(06) kJ mol^{-1} from 0.07 mol in (a)(ii) Allow kJ mol^{-} / J mol^{-} Ignore SF except 1 SF Ignore incorrect / missing units in M1 and M2 Correct answer with sign and units scores (3)	

Q7.

Question Number	Acceptable Answer	Additional Guidance	Mark
(a)	• suitable extrapolation (1) • ΔT in the range of 29 – 33(°C) (1)	Vertical at 3 minutes and smooth curve of best fit back from 10 minutes to 3 minutes  	**2**

Question Number	Acceptable Answer	Additional Guidance	Mark
(b) (i)	An explanation that makes reference to the following point: • as reaction is not instantaneous / takes time to release heat (1) • so some heat is lost as mixture heats up (1)		**2**

Question Number	Acceptable Answer	Additional Guidance	Mark
(b) (ii)	An explanation that makes reference to the following points: • by using more finely powdered zinc (1) • because it will increase the rate of reaction (1)	A greater surface area of zinc Less time for heat loss	**2**

Question Number	Acceptable Answer	Additional Guidance	Mark
(c)	• Calculation of Q using $Q = mc\Delta T$ (1) • amount of $CuSO_4(aq)$ (1) • energy per mol = Q/0.018 (1) • ΔH = -Q/1000 kJ mol^{-1} (1)	Using ΔT from (a) Example of calculation 25 x 4.18 x 30.5 = 3 187 (J) Allow 4.2 for 4.18 = 25/1000 x 0.720 = 0.018 3 187/0.018 = −177 kJ mol^{-1} / −180 kJ mol^{-1} / −177 000 J mol^{-1} / −180 000 J mol^{-1} Use of 4.2 gives −178 kJ mol^{-1} Must have correct sign and units for 4th mark	**4**

Question Number	Acceptable Answer	Additional Guidance	Mark
(d) (i)	• (217 – answer to (c) / 217) x 100	Example of calculation (217 – 177 / 217) x 100 = 18.4%	**1**

Question Number	Acceptable Answer	Additional Guidance	Mark
(d) (ii)	An answer that makes reference to **two** of the following points: • no lid is used (1) • SHC of solution may not be 4.18 (1) • energy absorbed by zinc / energy absorbed by thermometer / polystyrene cup (1) • mass of solution is greater than 25 grams (1)	If answer in (c) is less negative than -217, points one and three are valid, and for point two candidates must state less than 4.18 for SHC If answer in (c) is more negative than -217, only point two can be awarded for candidates stating SHC is greater than 4.18 Do not award marks for just 'heat loss to surroundings'	**2**

Question Number	Acceptable Answer	Additional Guidance	Mark
(d) (iii)	An explanation that makes reference to the following points: • ΔT would be less, so $\Delta_r H$ / enthalpy change calculated would be less negative (1) • because heat energy is transferred to greater volume of water than expected volume (1)		**2**

Q8.

Question Number	Acceptable Answer	Additional Guidance	Mark
	• calculation of heat produced **(1)** • calculation of amount (mol) of HNO_3 **(1)** • calculation of enthalpy change **(1)** • negative sign **and** units **and** answer to 2 / 1 SF **(1)**	Example of calculation heat produced = 50.0 x 4.18 x 6.8 = 1421.2(J) / 1.4212 (kJ) amount HNO_3 used = 25.0 x 1.00/1000 = 0.025 / 2.5 x 10^{-2} (mol) Ignore moles NaOH and total moles calculated enthalpy change = $\frac{1421.2}{0.025}$ = 56848 ($J\ mol^{-1}$) **or** = $\frac{1.4212}{0.025}$ = 56.848 ($kJ\ mol^{-1}$) TE on heat produced and amount **HNO_3** final answer −57 / −60 $kJ\ mol^{-1}$ **or** −57 000 / −60 000 $J\ mol^{-1}$ TE on enthalpy change Do not award 3 SF Correct final answer with sign, units and 2 or 1 SF but no working scores (4) Ignore units and sign of enthalpy change in M1 and M3	**(4)**

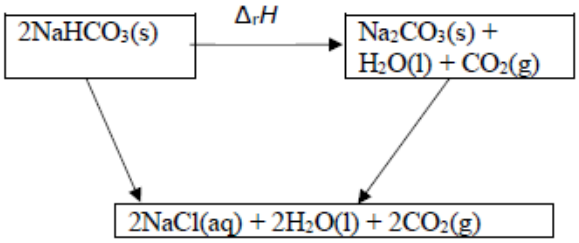
Q9.

Question Number	Answer	Additional guidance	Mark
(i)	An explanation that makes reference to the following points • C=C bond is weaker than 2 x C-C bond **(1)** • as it consists of a pi and a sigma bond (rather than 2 sigma bonds) **(1)**	Ignore pi bond formed by sideways / less effective orbital overlap	**(2)**

Question number	Answer	Additional guidance	Mark
(ii)	• calculation of energy required to break reactant bonds **(1)** • calculation of energy release when product bonds form **(1)** • calculation of enthalpy change **(1)**	Example of calculation: 5(C-H) + (C=C)+(C- C)+(C-O)+(O-H)+4(O=O) 5(413) + (612) + (347) + (358) + (464) + (4x498) = 5838 (kJ mol^{-1}) 6(C=O) + 6(O-H) (6x805) + (6x464) = 7614 (kJ mol^{-1}) 5838 – 7614 = –1776 (kJ mol^{-1}) Ignore SF except 1 SF Allow TE from M1 and M2 Correct answer no working scores 3	**(3)**

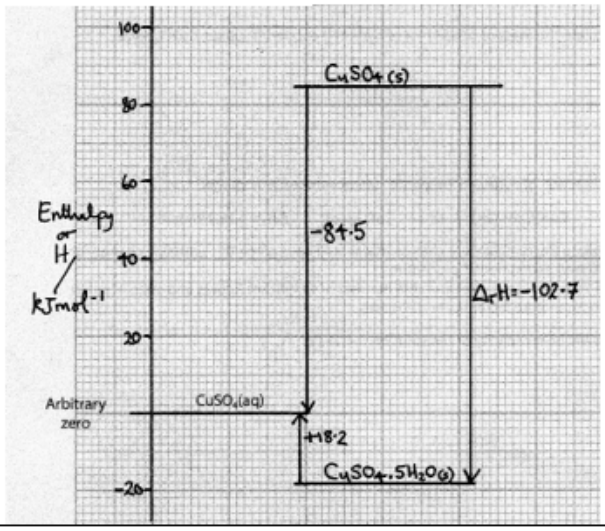
Question Number	Answer	Additional Guidance	Mark
(iii)	An explanation that makes reference to one of the following points EITHER • ΔS_{total} is always positive (1) **(1)** • As both $\Delta S_{surroundings}$ and ΔS_{system} are positive **(1)** • OR • ΔG is always negative **(1)** • as ΔH is negative and $\Delta S_{(system)}$ is positive **(1)**	If no marking points awarded allow 1 mark for idea that ΔS_{system} / $\Delta S_{surroundings}$ / entropy increases with correct explanation	**(2)**

Q10.

Question Number	Answer	Additional Guidance	Mark
(i)		Example of Hess cycle	(2)
	• correct species and balancing numbers in lower box (1)	Ignore missing state symbols	
	• both arrows pointing in correct directions (1)	Stand alone mark Ignore labels on arrows and inclusion of HCl	

Question Number	Answer	Additional Guidance	Mark
(ii)	• expression for $\Delta_r H$ (1) • substitution of values into expression with both values in same units (1) • calculation of $\Delta_r H$ **and** sign **and** units (1)	Example of calculation $\Delta_r H = 2x\Delta H_1 - \Delta H_2$ $\Delta_r H = 2 \times 20.619 - (-29.4)$ **or** $\Delta_r H = 2 \times 20619 - (-29\,400)$ M1 can be scored from values substituted into correct expression in M2 TE on ΔH_1 in (a)(iii) and expression in M1 No TE on incorrect arrows in cycle $\Delta_r H = +70.638$ kJ mol^{-1} **or** $\Delta_r H = +70638$ J mol^{-1} TE on ΔH_1 in (a)(iii) and expression in M1 provided it is a +ve answer Ignore SF except 1 SF Correct answer with sign and units scores (3)	(3)

Q11.

Question Number	Answer	Additional Guidance	Mark
(i)	• labelled y axis, including units, with appropriate scale **(1)** • direction and placement of enthalpy changes, +18.2 and −84.5 **(1)** • Entities with state symbols **(1)**	Allow energy for 'enthalpy' Ignore horizontal axis Do not award enthalpy change/ΔH for y axis Allow ΔH_1 and ΔH_2 for respective values Arrows must be shown and in the correct direction Ignore activation energy 'curves' Do not award double-headed arrows Ignore inclusion of '+ aq' <u>Example of diagram</u> 	**(3)**

Question Number	Answer	Additional Guidance	Mark
(ii)	• Use of Hess's law to calculate $\Delta_r H$ shown on the diagram	Value from diagram = −102.7 (kJ mol^{-1}) Allow $\Delta_r H = \Delta H_2 - \Delta H_1$ = −84.5 - (+18.2) = −102.7 (kJ mol^{-1}) Allow −103 (kJ mol^{-1}) Do not award if no working shown on the diagram	**(1)**

Q12.

Question Number	Answer	Additional Guidance	Mark
	• evaluation of Q **(1)** • rearrangement to give ΔT **(1)** • Answer to 1 or 2SF and temperature change **(1)**	Example of calculation $Q = (\Delta H \times n) = 18.2 \times 0.025 = 0.455$(kJ) or 455 **J** $\Delta T = Q \div (m \times c)$ $= 455 \div (45.00 \times 4.18)$ $= 2.4189...$(°C) ΔT = 2/2.4 °C/ K **and** decrease Allow -2/2.4 °C/ K Correct final answer without working scores (3) TE throughout	**(3)**

Q13.

Question Number	Answer	Additional Guidance	Mark
	An answer that makes reference to • Cannot react exactly 5 mol of water with 1 mol of anhydrous copper(II) sulfate	Cannot measure the temperature (change) for a **solid** Description that states more (than 5) water molecules will attach to some $CuSO_4$ while less (than 5) water molecules will attach to other $CuSO_4$ ACCEPT reasonable ideas such as some water may evaporate (due to exothermic reaction) Ignore heat loss to surroundings if given as an alternative reason Do not award heat is needed to start the reaction	**(1)**

Q14.

Question Number	Answer	Mark
	The only correct answer is C ***A*** *is not correct because standard enthalpy of formation is for making 1 moles of a compound* ***B*** *is not correct because standard enthalpy of formation is for making 1 moles of a compound* ***D*** *is not correct because* oxygen must be O_2	**(1)**

Q15.

Question Number	Acceptable Answer	Additional Guidance	Mark
	An answer that makes reference to the following point: • to make sure that (all) the (nitric) acid / HNO_3 / H^+ has reacted / been neutralised / is used up	Allow (nitric acid) / HNO_3 is the limiting reagent Allow so that 0.025 mol of water / H_2O forms Ignore to make sure that 1 mol of water / H_2O forms Ignore just 'to ensure that reaction is complete'	**(1)**

Q16.

Question Number	Answer	Additional Guidance	Mark
(i)	• calculation of percentage error	Example of calculation percentage error $= \frac{(90 - 74)}{90} \times 100 = 17.778$ / 17.8 / 18(%) Allow 17.7 recurring Ignore SF except 1SF Do not award 17.7	(1)

Question Number	Answer	Additional Guidance	Mark
(ii)	• calculation of percentage uncertainty using measuring cylinder **and** burette	Example of calculation percentage uncertainty using measuring cylinder $= \frac{0.5 \times 100}{50} = 1(\%)$ **and** percentage uncertainty using burette $= \frac{2 \times 0.05}{50} \times 100 = 0.2(\%)$ Ignore SF / ±	(1)

Question Number	Answer	Additional Guidance	Mark
(iii)	An answer that makes reference to the following point • the difference in the uncertainty in using the burette compared with the measuring cylinder is very much smaller than the % error in the value obtained (so other factors are more significant)	Allow the uncertainty using the burette is not **significantly** less than using the measuring cylinder Allow uncertainty represents a spread of values whereas the error is the difference of the true value and value obtained Allow just 'hydrochloric acid / HCl is in excess' Ignore heat loss	(1)

Question Number	Answer	Additional Guidance	Mark
(iv)	A description that makes reference to the following points: • measure the temperature of the (hydrochloric) acid every 30 s for 2½ minutes (1) • add the sodium carbonate / solid (at exactly 3 minutes) (1) • (stir and) measure the temperature (of the mixture) every 30 s for another 5 minutes (1) • plot a graph of temperature against time (1) • (join the two sets of points with 2 best fit straight lines and) extrapolate the lines to the time of mixing **and** determine the maximum temperature change / rise at that time	Allow different times in M1, M2 and M3 or measure the temperature at regular time intervals Allow use of a lid / additional insulation M4 & M5 can be awarded from a suitably labelled sketch graph	(5)

Q17.

Question Number	Answer	Mark
(i)	**The only correct answer is D** ***A*** *is not correct because the measurement uncertainty is doubled as there are two burette readings* ***B*** *is not correct because this gives the largest measurement uncertainty* ***C*** *is not correct because the measurement uncertainty is doubled as the pipette is used twice*	**(1)**

Question Number	Answer	Additional Guidance	Mark
(ii)	calculation of Q **(1)** calculation of enthalpy change **(1)** answer to nearest whole number **and** with negative sign **(1)**	<u>Example of calculation</u> Q=(100 x 4.18 x 6.5=) = 2717 (J) / 2.717 kJ ΔH= 2.717 ÷ 0.05= (–)54.340 = –54 (kJ mol^{-1}) Allow TE at each stage Correct answer with no working scores (3)	**(3)**

Q18.

Question Number	Answer	Mark
(i)	**The only correct answer is B** ***A*** *is not correct because there is no extrapolation to the largest temperature increase carried out* ***C*** *is not correct because the extrapolation is at the wrong time* ***D*** *is not correct because the extrapolation extends beyond the time of addition of alkali*	**(1)**

Question Number	Answer	Additional Guidance	Mark
(ii)	An explanation that makes reference to • ethanoic acid is a weak(er) acid / only partially ionised/dissociated **(1)** • (some) **energy** is used to fully/completely ionise the ethanoic acid **(1)**	Allow hydrochloric acid is a strong(er) acid/fully ionised Do not award 'more NaOH will react so more energy given off'	**(2)**