Questions

Q1.

Students are investigating exothermic and endothermic reactions.

They are finding the temperature change in 50 cm3 water when a solid dissolves in it.
The apparatus is shown in Figure 1.

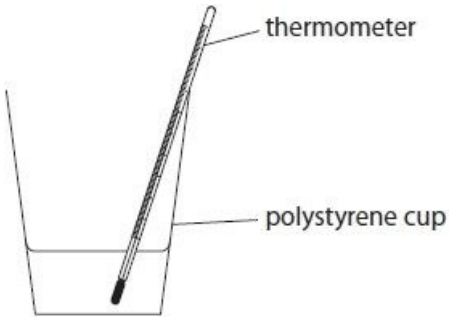


Figure 1

The steps needed to carry out this experiment are P, Q, R, S and T.

They are shown below.

They are not in the correct order.

P pour the 50 cm3 water into the polystyrene cup
Q add the solid to the water and stir
R measure 50 cm3 water using a beaker
S vmeasure the initial temperature of the water
T measure the final temperature of the solution when all the solid has dissolved

Write the steps in the correct order, from left to right.

(2)

☐ ☐ ☐ ☐ ☐

(Total for question = 2 marks)

Q2.

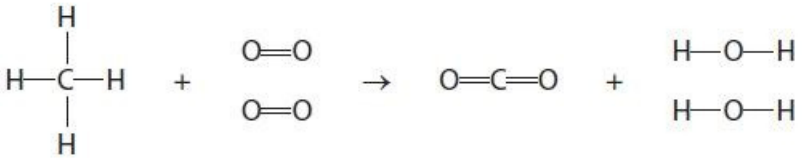
The energies of some bonds are shown in Figure 8.

bond	bond energy in kJ mol^{-1}
C—H	435
O=O	496
C=O	805
H—O	463

Figure 8

Methane burns in oxygen to form carbon dioxide and water.

The equation shows the structures of the molecules.



Calculate the energy change, in kJ mol $^{-1}$, for this reaction.

(4)

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energy change = ... kJ mol $^{-1}$

(Total for question = 4 marks)

Q3.

Some questions must be answered with a cross in a box (☒). If you change your mind about an answer, put a line through the box (☒) and then mark your new answer with a cross (☒).

In some chemical reactions, bonds are broken in the reactant molecules and new bonds are formed to make the product molecules.

(i) Which row is correct about the energy changes for these processes?

(1)

		energy change	
		breaking a bond	**making a bond**
☒	**A**	energy is released	energy is released
☒	**B**	energy is released	energy is absorbed
☒	**C**	energy is absorbed	energy is released
☒	**D**	energy is absorbed	energy is absorbed

(ii) Hydrogen reacts with fluorine.

$$H2 + F2 \rightarrow 2HF$$

Figure 12 shows the bond energies for the bonds in the three molecules in the equation.

bond	bond energy in kJ mol^{-1}
H—H	436
F—F	158
H—F	562

Figure 12

Calculate the energy change for this reaction.

(4)

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energy change = ... kJ mol^{-1}

(Total for question = 5 marks)

Q4.

Crude oil is a complex mixture of substances.

When crude oil is separated into fractions, the amount of each fraction obtained rarely matches the demand for that fraction.
Figure 9 shows the relative amounts of six of the fractions present in a crude oil and the relative demand for each of these fractions.

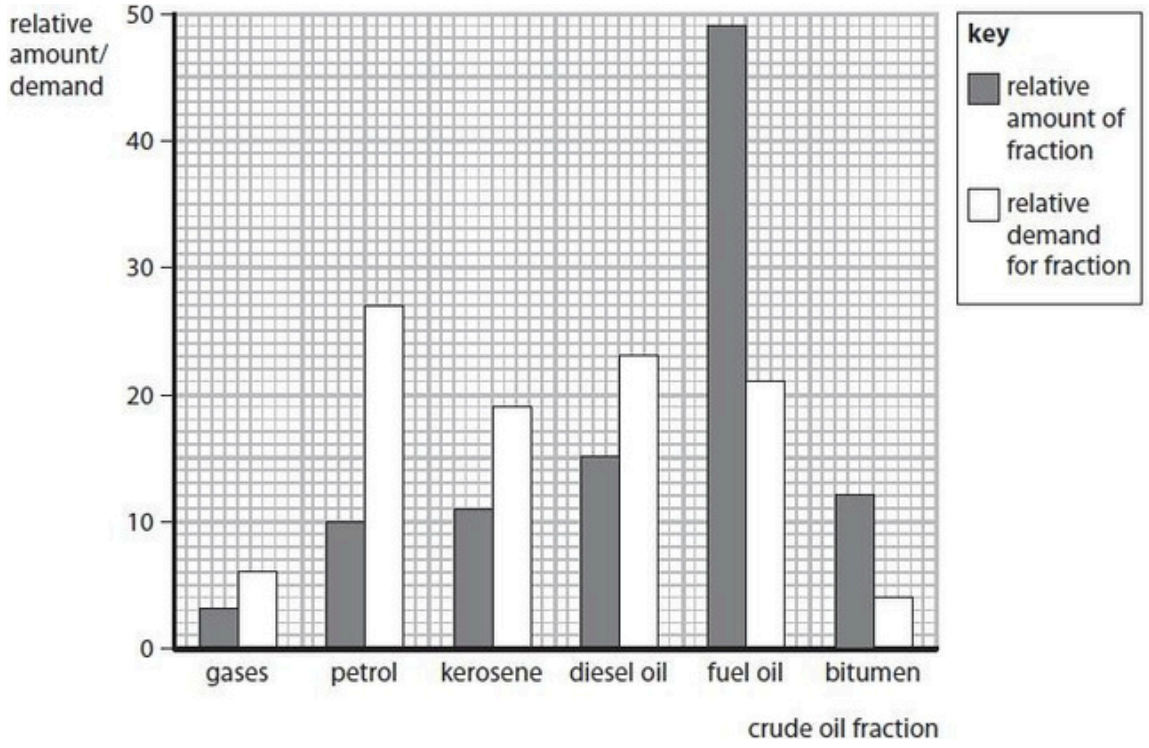

Figure 9

Cracking is used to match the relative amount of a fraction of crude oil to the demand for that fraction.
(i) Use the information in Figure 9 to give the name of the fraction that is most likely to need to be cracked.

(1)

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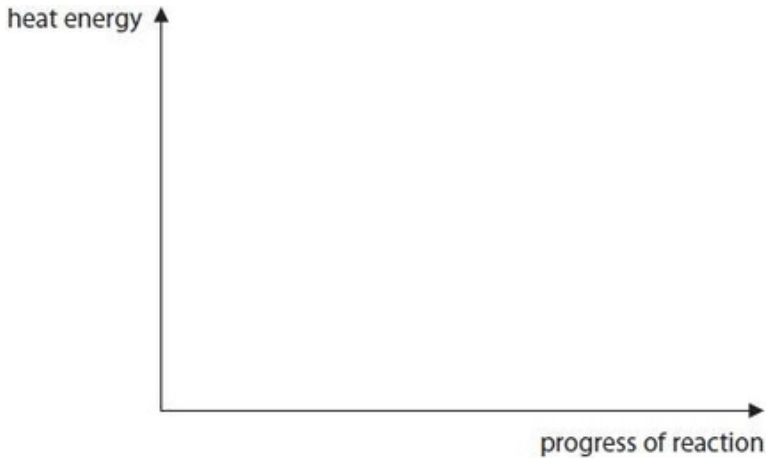
(ii) In a cracking reaction, reactants are heated to form products.
This reaction is endothermic.

On the axes provided, draw the reaction profile of this reaction.

Label the energy of the reactants, the energy of the products and the activation energy of the reaction.

(3)



(iii) Dodecane, C12H26, can be cracked to form useful products.

Complete the equation for the cracking of dodecane by filling in the formula of the single molecule needed to balance the equation.

(1)

$$C_{12}H_{26} \rightarrow \text{.....} + 3C_2H_4$$

(Total for question = 5 marks)

Q5.

Hydrogen reacts with oxygen to form steam.

$$2H_2(g) + O_2(g) \rightarrow 2H_2O(g)$$

Bond energies are shown in Figure 14.

bond	bond energy in kJ mol^{-1}
H—H	435
O═O	500
O—H	460

Figure 14

Calculate the energy change for the reaction of 2 mol of hydrogen gas, H_2, with 1 mol of oxygen gas, O_2, to give 2 mol of steam, H_2O.

(4)

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energy change = ... kJ mol^{-1}

(Total for question = 4 marks)

Q6.

Students are investigating exothermic and endothermic reactions.
They are finding the temperature change in 50 cm3 water when a solid dissolves in it.
The apparatus is shown in Figure 1.

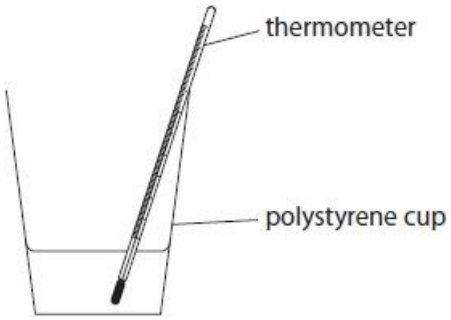

Figure 1

The dissolving of this solid in water is an exothermic change.

The experiment is repeated a number of times.
Compared with the initial temperature of the water, the final temperature of the solution is

(1)

- ☒ A always higher
- ☒ B always lower
- ☒ C sometimes higher and sometimes lower
- ☒ D always unchanged

(Total for question = 1 mark)

Q7.

Dissolving ammonium chloride in water is an endothermic process.
Figure 17 shows part of the reaction profile for this process.

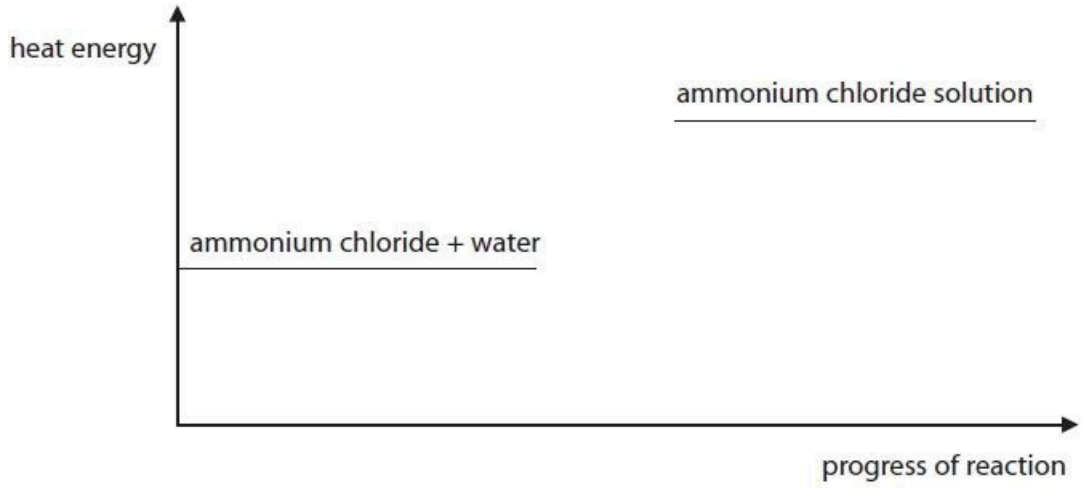

Figure 17

(i) Explain how Figure 17 shows that dissolving ammonium chloride in water is an endothermic process.

(2)

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(ii) Complete the reaction profile in Figure 17 and label the activation energy.

(2)

(Total for question = 4 marks)

Q8.

A student poured 50 cm3 water into a beaker and measured the water's temperature.

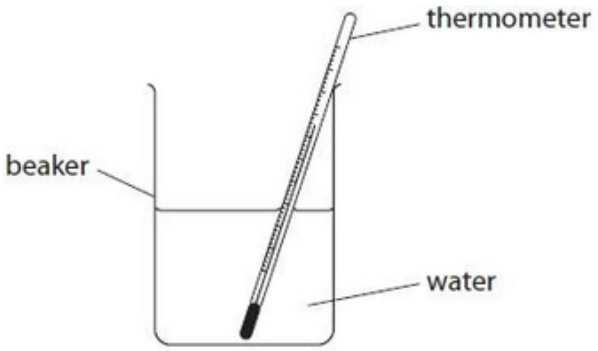

Figure 7

The student added 1.00 g calcium chloride to the water, stirred the mixture and then recorded the temperature.
The student's results were

temperature of water at start	= 21 °C
temperature of mixture after stirring	= 32 °C

Explain, using these results, the type of heat energy change that occurs when calcium chloride dissolves in water.

(2)

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(Total for question = 2 marks)

Q9.

Calcium carbonate reacts with dilute hydrochloric acid to produce calcium chloride, water and carbon dioxide.

$$CaCO3 + 2HCl \rightarrow CaCl2 + H2O + CO2$$

The reaction between calcium carbonate and dilute hydrochloric acid is exothermic.

Explain, in terms of bond breaking and bond making, why some reactions are exothermic.

(3)

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(Total for question = 3 marks)

Q10.

A student poured 50 cm3 water into a beaker and measured the water's temperature.

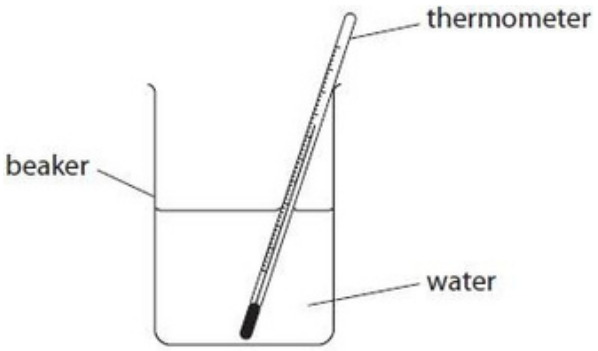

Figure 7

The student added 1.00 g calcium chloride to the water, stirred the mixture and then recorded the temperature.

Give the name of the apparatus that could be used to measure 1.00 g of calcium chloride.

(1)

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(Total for question = 1 mark)

Q11.

Some reactions are exothermic and some reactions are endothermic.

In an experiment, a solid is mixed with a liquid.
The temperature change of the mixture is measured.
Figure 6 shows the apparatus that is used.

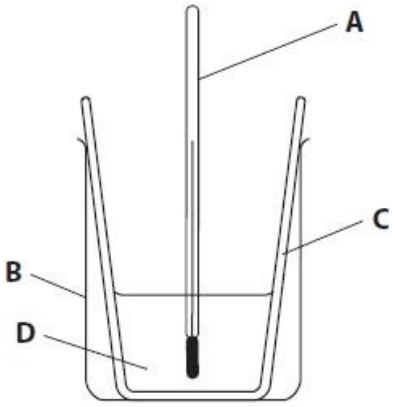

Figure 6

(i) Give the letter of the piece of apparatus, A, B, C or D, in Figure 6 that is used to measure the temperature.

(1)

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(ii) Give the name of the piece of apparatus B shown in Figure 6.

(1)

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(iii) The piece of apparatus labelled C is made from polystyrene.

State why polystyrene is a better material than glass for this piece of apparatus.

(1)

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(iv) The results of the experiment are given in Figure 7.

temperature of liquid at start in °C	18.6
temperature of products at end in °C	16.1

Figure 7

Calculate the change in temperature.
Give a sign and a unit in your answer.

(3)

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.....

temperature change = ...

(v) The solid used in this experiment contained only NH_4^+ ions and NO_3^- ions.

Give the formula and the name of the solid.

(2)

formula .....

name .....

(Total for question = 8 marks)

Q12.

In another experiment, a student investigated the temperature decrease when different amounts of ammonium nitrate crystals were dissolved in 100 cm3 of water.

The apparatus used is shown in Figure 5.

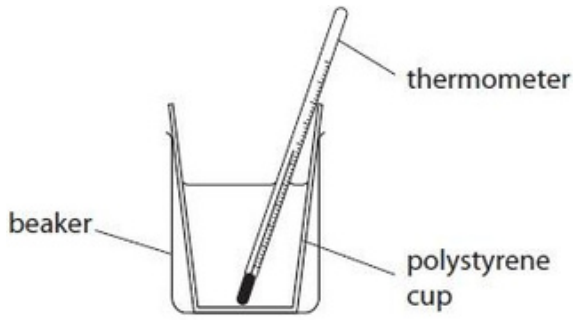

Figure 5

The student used the following method.

step 1 pour 100 cm3 of water into the polystyrene cup
step 2 add one spatula of ammonium nitrate crystals to the water
step 3 stir the mixture
step 4 use the thermometer to record the lowest temperature reached by the mixture
step 5 repeat steps 1 to 4 using different amounts of ammonium nitrate

(i) Name a piece of apparatus that should be used to measure the 100 cm3 of water in step 1.

(1)

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(ii) The student cannot work out the temperature decrease using the method described.

State what the student must do before step 2 to be able to work out the temperature decrease.

(1)

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(iii) State why a polystyrene cup is used in this experiment.

(1)

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(iv) Figure 6 shows the reaction profile for this reaction.

Use the words from the box to complete the labels on Figure 6.

activation energy	products	reactants

(2)

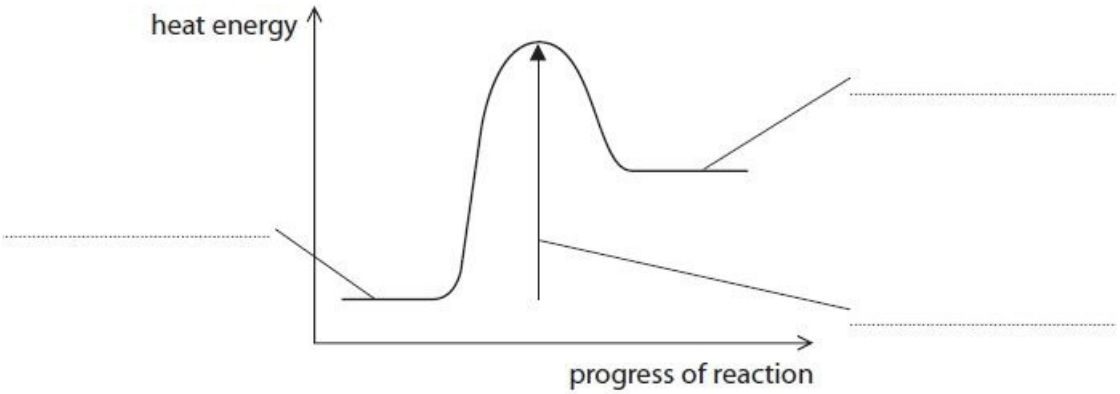

Figure 6

(Total for question = 5 marks)

Q13.

Students are investigating exothermic and endothermic reactions.
They are finding the temperature change in 50 cm3 water when a solid dissolves in it.
The apparatus is shown in Figure 1.

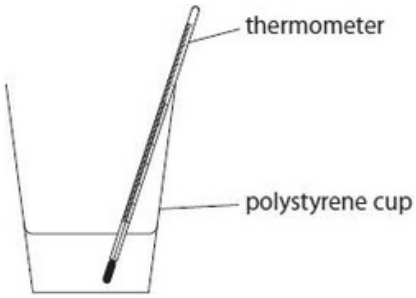

Figure 1

Figure 2 shows a cold pack.

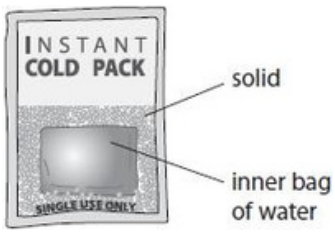

Figure 2

When the pack is squeezed hard the inner bag bursts.
Then the pack goes cold.
(i) Explain why the pack goes cold.

(2)

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(ii) Give the reason why the pack can be used only once.

(1)

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(Total for question = 3 marks)

Q14.

A student poured 50 cm3 water into a beaker and measured the water's temperature.

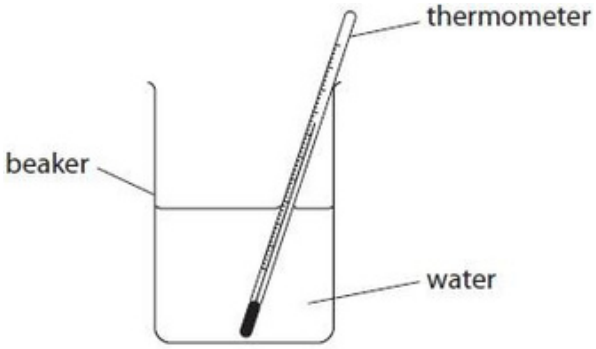

Figure 7

The student added 1.00 g calcium chloride to the water, stirred the mixture and then recorded the temperature.
State one way in which the apparatus could be changed to reduce the amount of heat energy lost during the experiment.

(1)

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(Total for question = 1 mark)

Q15.

Figure 11 shows the reaction of propene, C3H6, with water.

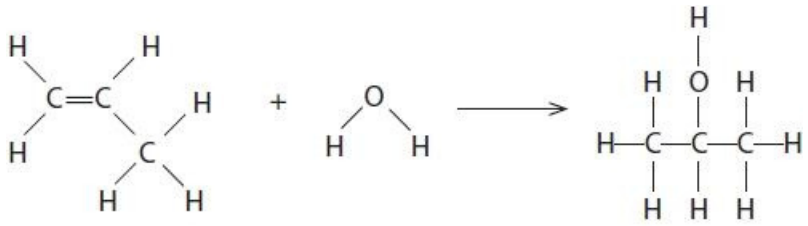

Figure 11

Figure 12 shows some bond energies.

bond	bond energy in kJ mol^{-1}
C—C	347
C—O	358
C—H	413
O—H	464
C=C	612

Figure 12

Use the bond energies in Figure 12 to calculate the energy change of the reaction in Figure 11.

(4)

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energy change of reaction = ... kJ mol^{-1}

(Total for question = 4 marks)

Q16.

The first four elements in group 1 are lithium, sodium, potassium and rubidium.

An example of an endothermic reaction is the reaction between rubidium hydroxide and ammonium carbonate, $(NH_4)_2CO_3$.
This reaction forms rubidium carbonate, Rb_2CO_3, ammonia and one other product.

Write the balanced equation for this reaction.

(3)

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(Total for question = 3 marks)

Mark Scheme

Q1.

Question Number	Answer	Mark
	R P S Q T R P S as first 3 (1) Q T as last 2 (1)	**(2)** AO 3 2a AO 3 2b

Q2.

Question number	Answer	Additional guidance	Mark
	-730 as final answer with or without working scores 4 +730 as final answer with or without working scores 3 bonds broken = (4 x 435) + (2 x 496) = 2732 **(1)** bonds made = (2 x 805) + (4 x 463) = 3462 **(1)** energy change = broken – made **(1)** [2732 – 3462] = -730 (kJ mol^{-1}) **(1)**	allow ECF	**(4)**

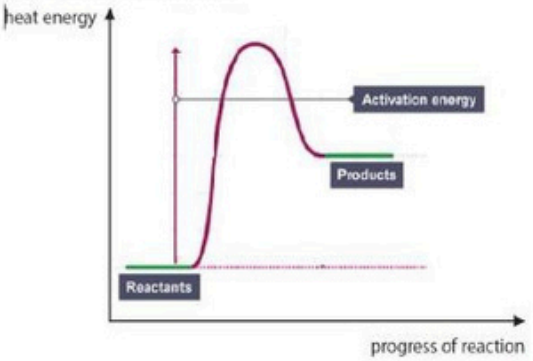
Q3.

Question number	Answer	Mark
(i)	**C** energy is absorbed energy is released is the only correct answer. **B, C** and **D** are incorrect because at least one energy change is reversed.	**(1)** **AO1 1**

Question number	Answer	Additional guidance	Mark
(ii)	• energy change in reactants = 436 + 158 (= 594) (1) • energy change in products = 2 x 562 (= 1124) (1) • overall energy change = 594 – 1124 (1) • = -530 (1) (kJ mol^{-1})	allow ECF throughout ignore sign/unit in MP1 ignore sign/unit in MP2 MP3 for the difference between MP1 and MP2 ignore sign / unit in MP3 MP4 for correct sign or stating exothermic / endothermic based on MP3 (+)530 scores 3 marks (loses MP4) (+)64 scores 3 marks (MP1 doubled) -64 scores 2 marks (MP1 doubled and loses MP4) (+)32 scores 3 marks (MP2 not doubled) -32 scores 2 marks (MP2 not doubled and loses MP4)	(4) AO2 1

Q4.

Question Number	Answer	Mark
(i)	fuel oil	(1) AO 3 2a

Question Number	Answer	Additional guidance	Mark
(ii)	• reactant(s) and product(s) labelled in their correct positions (1)	example of diagram 	(3) AO 1 1
	• activation energy labelled (1)	ignore arrow heads	
	• energy of reactants lower than energy of products (1)	allow unlabelled diagram of an endothermic reaction showing the basic outline shape if exothermic reaction profile shown, allow (1) for reactants and products in correct position and (1) for correct labelling of activation energy	

Question Number	Answer	Additional guidance	Mark
(iii)	C_6H_{14}		(1) AO 2 1

Q5.

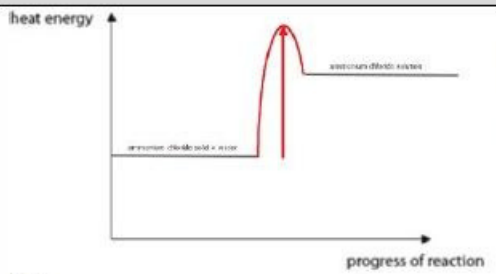
Question Number	Answer	Additional guidance	Mark
	award full marks for correct numerical answer without working energy needed to break bonds = (2 x 435) + (1 x 500) = 1370 (kJ mol^{-1}) (1) energy released when bonds are formed = 4 × 460 = 1840 (1) energy change = 1370 – 1840 = (-) 470 (kJ mol^{-1}) (1) negative sign or 'energy released' (1)	 allow 1840 - 1370 = 470 (1) ignore sign allow exothermic (reaction) final answer 450 award 2 marks -450 award 2 marks final answer +450 award 3 marks	(4) AO 2 1

Q6.

Question Number	Answer	Mark
	A always higher **The only correct answer is A** ***B** is not correct because temperature rise* ***C** is not correct because temperature always rises* ***D** is not correct because temperature rises*	**(1)** AO 2 2

Q7.

Question number	Answer	Additional guidance	Mark
(i)	an explanation linking two of: • {ammonium chloride solution/product} has more energy than {ammonium chloride solid and water/reactant} / ORA (1) • heat (energy) has increased / energy change is positive (1) • (therefore) heat energy has been {absorbed/taken in} (1)	ignore arguments about bond making / bond breaking	**(2)** **AO3**

Question number	Answer	Additional guidance	Mark
(ii)	 (2)	curve from reactants to products with peak higher than product energy (1) arrow labelled activation energy on correct curve (1)	**(2)** **AO2**

Q8.

Question number	Answer	Additional guidance	Mark
	An explanation linking • temperature rises / increases (by 11 °C) (1) • exothermic process (1)	 allow gets hotter / water heats up {temperature / it} goes up Ignore heat increasing for MP1 allow heat / energy {given out / released to surroundings} reject endothermic for MP2	**(2)**

Q9.

Question number	Answer	Additional guidance	Mark
	an explanation linking breaking bonds {needs energy/ endothermic} (1) making bonds {releases energy/ exothermic} (1) more energy is **given out** than is **taken in** (1)	allow heat for energy Ignore refs to energy level diagrams ignore refs to number of bonds made/broken	**(3)**

Q10.

Question number	Answer	Additional guidance	Mark
	(top pan) balance (1)	allow (weighing) scale(s)	**(1)**

Q11.

Question number	Answer	Mark
(i)	A / thermometer	**(1)** **AO2 2**

Question number	Answer	Additional guidance	Mark
(ii)	**beaker**	allow measuring beaker/ plastic beaker reject measuring cup/ jug	**(1) AO2 2**

Question number	Answer	Additional guidance	Mark
(iii)	it is a (good heat) insulator	allow would hold / trap heat / keeps heat in / doesn't absorb heat / reduces heat loss / poor conductor allow correct comparison of heat conductivity with glass e.g polystyrene is a better insulator than glass ignore keeps temperature in / heat resistant ignore not breakable / glass is breakable ignore 'traps energy' alone	**(1) AO2 2**

Question number	Answer	Additional guidance	Mark
(iv)	-2.5℃ scores 3 with or without working 16.1 – 18.6 (1) = -2.5 (1) ℃ (1)	2.5℃ scores 2 with or without working 2.5 scores 1 with or without working MP3 standalone mark ignore 'C' / 'o' alone ignore 'deg C'	**(3) AO2 1**

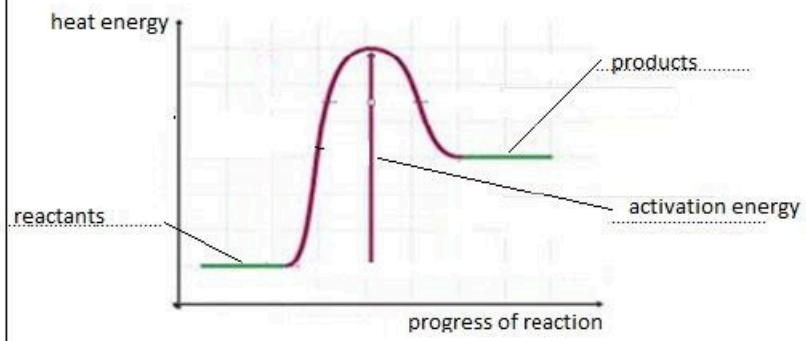
Question number	Answer	Additional guidance	Mark
(v)	formula: NH_4NO_3 (1) name: ammonium nitrate (1)	letters must be capitals and 4, 3 must be subscripts allow $NH_4^+NO_3^-$ allow $N_2H_4O_3$ ignore state symbols ignore $NH_4^+ + NO_3^-$ reject ammonia nitrate	**(2) AO2 1**

Q12.

Question number	Answer	Additional guidance	Mark
(i)	measuring cylinder / (volumetric) pipette / burette	ignore dropping pipette / beaker	(1)

Question number	Answer	Additional Guidance	Mark
(ii)	measure the initial temperature (of the water)	allow subtract initial temperature from final temperature OR vice versa allow temperature before mixing	(1)

Question number	Answer	Additional Guidance	Mark
(iii)	insulator / reduces heat transfer / poor conductor of heat	ignore references to heat loss	(1)

Question number	Answer	Mark
(iv)	• any one label correct (1) • all three labels correct (1) 	(2)

Q13.

Question Number	Answer	Additional guidance	Mark
(i)	An explanation including • the solid {dissolves/ reacts with the water} (1) • {takes in /absorbs} heat / is endothermic (1)	Ignore just 'a (chemical) reaction occurs' etc allow energy for heat ignore reference to temperature change	(2) AO 2 1

Question Number	Answer	Additional guidance	Mark
(ii)	(reaction) irreversible	allow **reaction** can only occur once allow reactants are used up / reaction is complete /the reaction has happened allow bag can only burst once/ cannot get water back into bag	(1) AO 3 1a

Q14.

Question number	Answer	Additional guidance	Mark
	put a lid on / put cover on top / lag beaker / use insulation / use polystyrene cup (1)	allow any material around the beaker that prevents heat loss eg cotton wool /(aluminium) foil	(1)

Q15.

Question number	Answer	Additional guidance	Mark
	bonds broken = C=C + O-H = 612 + 464 (1) (= 1076 (kJ mol^{-1})) bonds formed = C-C + C-O + C-H = 347 + 358 + 413 (1) (= 1118 (kJ mol^{-1})) energy change of reaction = 1076 − 1118 (1) = - (1) (42 (kJ mol^{-1}))	answer of - 42 (kJ mol^{-1}) scores 4 marks answer of (+) 42 (kJ mol^{-1}) scores 3 marks bonds broken = C=C + C-C + 6 C-H + 2 O-H = 612 + 347 + 6x413 + 2x464 (1) (= 4365 (kJ mol^{-1})) bonds formed = 2C-C + 7C-H + C-O + O-H = 2x347 + 7x413 + 358 + 464 (1) (= 4407 (kJ mol^{-1})) Energy change = 4365 − 4407 (1) = - (1) (42 (kJ mol^{-1}))	**(4)** **AO2**

Q16.

Question number	Answer	Mark
	$(NH_4)_2CO_3 + 2RbOH \rightarrow Rb_2CO_3 + 2NH_3 + 2H_2O$ **(3)** Four formulae on correct side of equation (regardless of any other formulae, correct or otherwise) **(1)** Equation with all five formulae and no others **(2)** Fully correct balanced equation **(3)** do not penalise incorrect subscripts/ superscripts/ small letters/ capital letters. Ignore state symbols.	**(3)**