Write your name, centre number and candidate number in the boxes below.

Surname	Other names

Centre number | | | | | |

Candidate number | | | | |

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Chemical energetics

Time allowed: 40 minutes

Subject code **0620**

Chemistry

Questions from Paper 1, Paper 2, Paper 3, Paper 4 and Paper 6

You must have: a ruler marked in centimetres and millimetres, a protractor, compasses, a pen, an HB pencil and an eraser.

Total marks

/ 34

Instructions

- Answer every question in the space provided on this paper.
- Write in black or dark blue ink. Pencil may be used for diagrams and graphs.
- Fill in your name, centre number and candidate number above.
- Show your working: a correct method can earn marks even if the answer is wrong.

Information

- This paper has 10 questions worth 34 marks in total.
- The marks for each question or part are shown in brackets, for example [3].

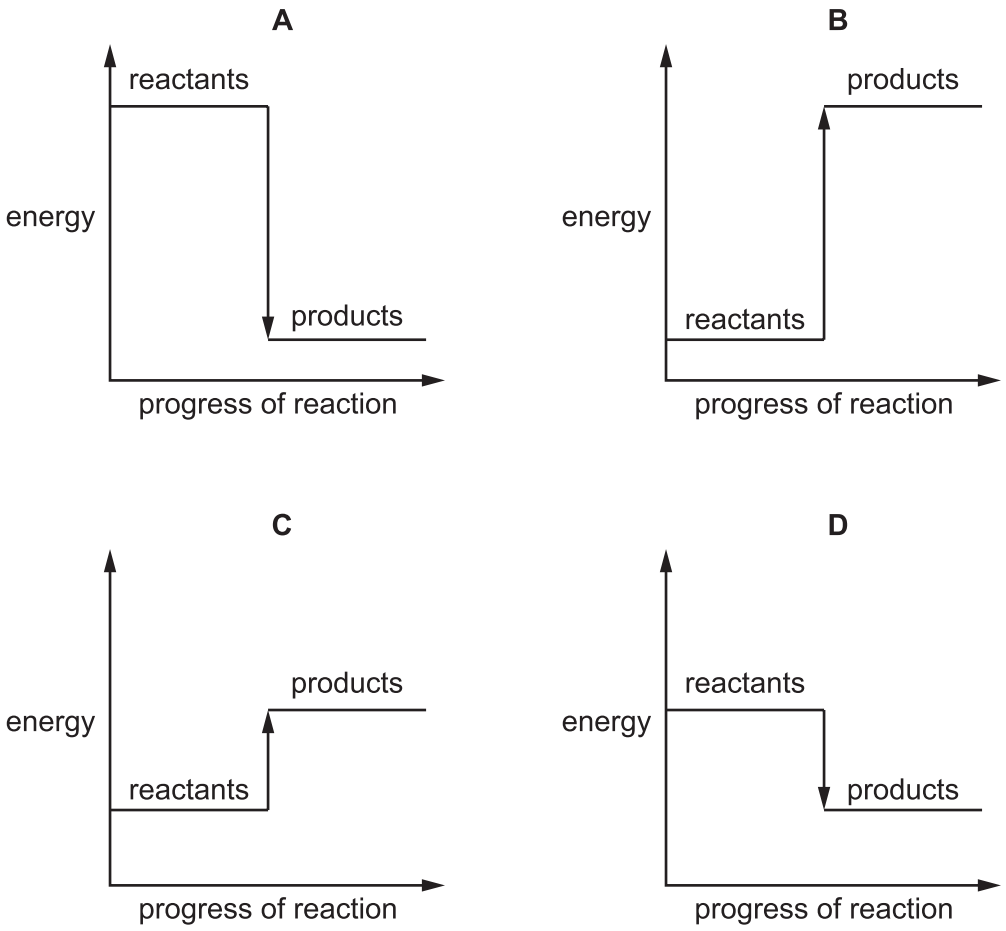
Advice

- Read every question through once before you write anything.
- Use the marks in brackets to judge how long to spend on each part.
- If you finish early, go back and check your working.

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Print at 100% (Actual size) so diagrams keep their real measurements.

1 Which energy level diagram shows the reaction that will give out the most energy?



Exothermic and endothermic reactions Click for more variations

Answer A

2 Which statement about chemical reactions is correct?

A Endothermic reactions show a temperature decrease because energy is absorbed from the surroundings.

B Endothermic reactions show a temperature increase because energy is released into the surroundings.

C Exothermic reactions show a temperature increase because energy is absorbed from the surroundings.

D Exothermic reactions show a temperature decrease because energy is released into the surroundings.

Exothermic and endothermic reactions Click for more variations

Answer A

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3 When ammonium nitrate is added to water, the temperature of the mixture decreases.

The ammonium nitrate can be recovered by evaporating the water.

Which statement explains these observations?

A The ammonium nitrate dissolves in the water, and the process is endothermic.

B The ammonium nitrate reacts with the water, and the process is endothermic.

C The ammonium nitrate dissolves in the water, and the process is exothermic.

D The ammonium nitrate reacts with the water, and the process is exothermic.

Physical and chemical changes Click for more variations

Answer A

4 Two statements about hydrogen are listed.

1 Hydrogen is used as a fuel.

2 When hydrogen burns in the air to form water, thermal energy is produced.

Which conclusion about these statements is correct?

A Both statements are correct, and statement 2 explains statement 1.

B Both statements are correct, but statement 2 does **not** explain statement 1.

C Statement 1 is correct, but statement 2 is **not** correct.

D Statement 2 is correct, but statement 1 is **not** correct.

Exothermic and endothermic reactions Click for more variations

Answer A

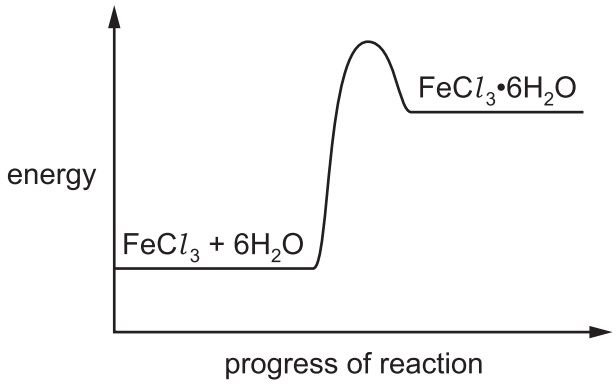
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5 When water is added to anhydrous iron(III) chloride, $FeCl_3$, hydrated iron(III) chloride, $FeCl_3 \cdot 6H_2O$, is formed and energy is given out.

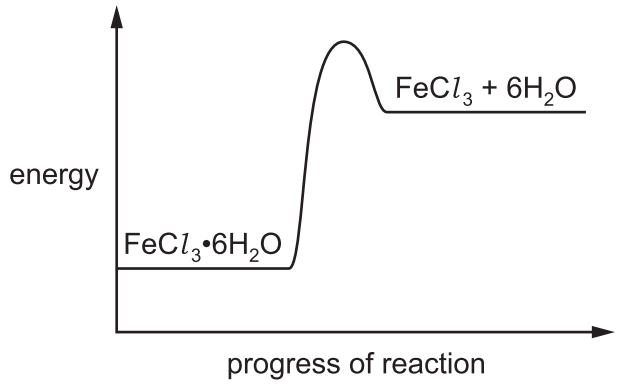
$$FeCl_3 + 6H_2O \rightleftharpoons FeCl_3 \cdot 6H_2O$$

Which reaction pathway diagram represents the formation of anhydrous iron(III) chloride in the **reverse** reaction?

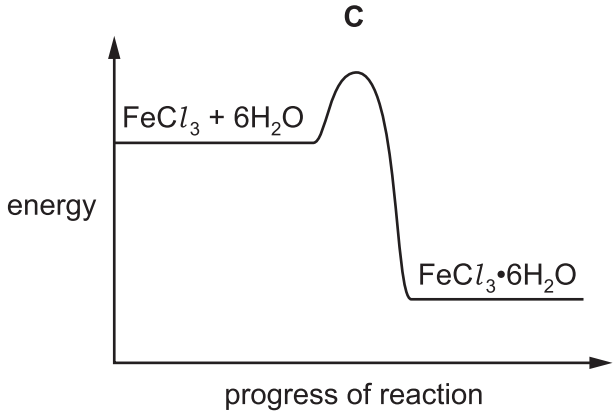
A



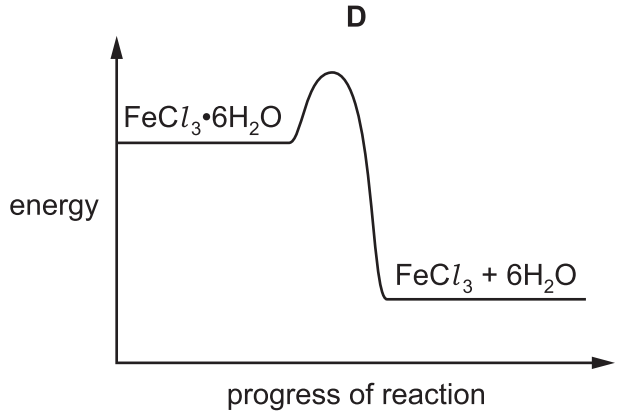
B



C



D

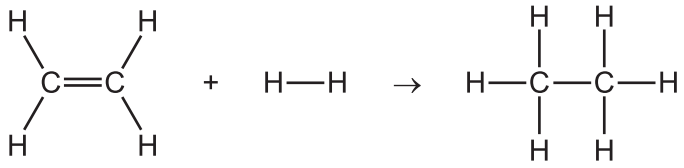


Exothermic and endothermic reactions Click for more variations

Answer B

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6 Ethene reacts with hydrogen to form ethane.



The bond energies are shown in the table.

bond	bond energy in kJ / mol
C–C	+350
C–H	+410
H–H	+436
C=C	+614

What is the enthalpy change for the reaction?

A –290 kJ / mol

B –120 kJ / mol

C +120 kJ / mol

D +290 kJ / mol

Bond energies Click for more variations

Answer B

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7 This question is about chemical reactions and their energy changes.

(a) Tick (✓) **one** box that shows a chemical change.

boiling ethanol	☐
decomposing vegetation	☐
dissolving salt	☐
mixing ink and water	☐

[1]

(b) Table 6.1 shows the results of four experiments.

Table 6.1

experiment	initial temperature / °C	final temperature / °C
1	20	14
2	18	26
3	19	25
4	17	12

(i) State which experiment shows the greatest temperature change.

..... [1]

(ii) State which experiment is the most endothermic.

..... [1]

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(iii) Fig. 6.1 shows an incomplete reaction pathway diagram for an exothermic reaction.

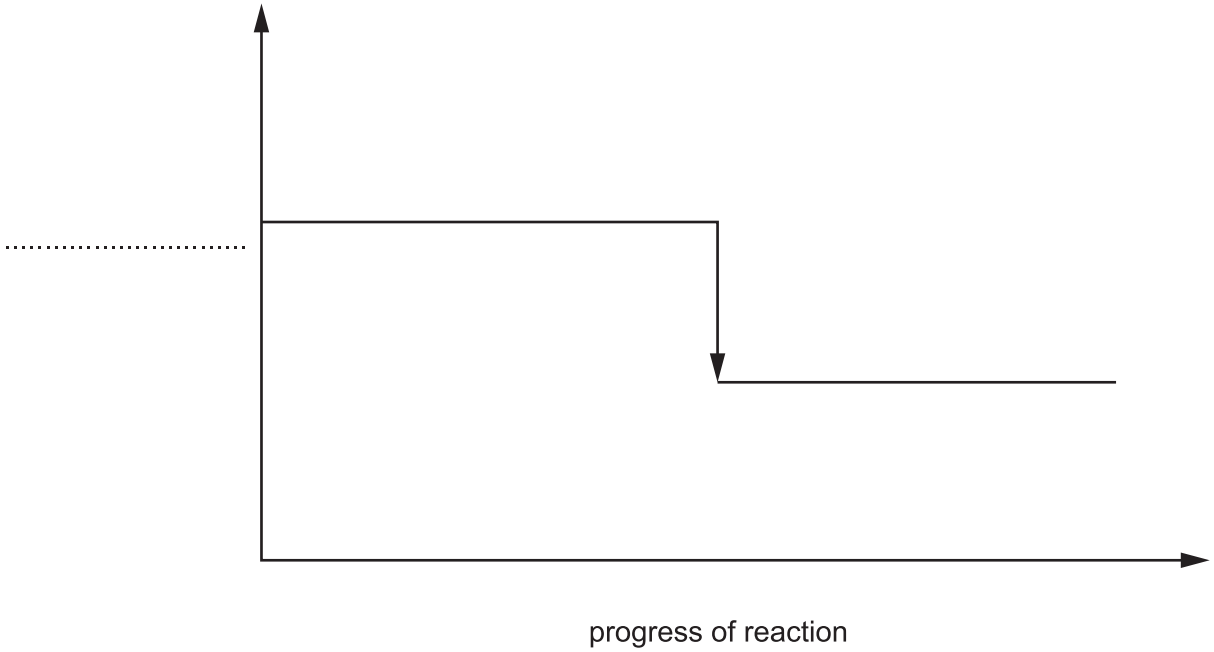


Fig. 6.1

Complete Fig. 6.1 by labelling:

- the vertical axis
- the reactants
- the products. [2]

[Total: 5]

Exothermic and endothermic reactions Click for more variations

Reduced to 77% to fit the page (wider than A4).

7(a)	decomposing vegetation (second box down ticked).	**1**
7(b)(i)	Experiment 2	**1**
7(b)(ii)	Experiment 1	**1**
7(b)(iii)	label on y-axis – energy (1) reactants on left hand line and products on right hand line on the graph (1)	**2**

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8 Liquid alcohols can be burned as fuels in spirit burners. The energy given out can be used to heat water in a boiling tube as shown in Fig. 4.1.

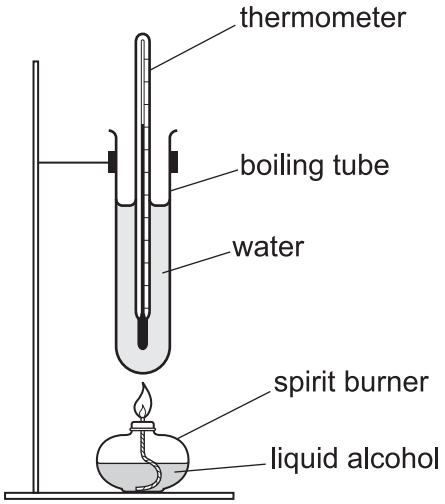


Fig. 4.1

Describe how to investigate which of three liquid alcohols, ethanol, propanol and butanol, heats the water in the boiling tube the fastest.

You are provided with three spirit burners, samples of the three alcohols, water and common laboratory apparatus.

.....

.....

.....

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.....

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.....

.....

..... [6]

Exothermic and endothermic reactions Click for more variations

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8	There are two valid approaches, either measuring time for a set temperature increase OR measuring temperature increase in a set time. *any 6 from*: **MP1** specified/set/measured volume water **MP2** measure (start/initial) temperature (of water) **MP3** volume of water measured using a measuring cylinder or burette or (volumetric) pipette AND **HEAT TO SET TEMPERATURE (change)** **MP4** start timing when heating started / burner put under tube **MP5** heat to set temperature / set temperature rise **MP6** record/measure time taken to heat water **MP7** shortest time is fuel that heats fastest OR **HEAT FOR A SET TIME** **MP4** heat water for a specified time **MP5** measure final temp of water **MP6** calculate temperature rise **MP7** highest temperature (rise) is fuel that heats fastest	**6**

9 **(a)** The following are two examples of substitution reactions. Only the reaction involving chlorine is a photochemical reaction.

$$CH_4 + Cl_2 \rightarrow CH_3Cl + HCl$$

$$CH_4 + Br_2 \rightarrow CH_3Br + HBr$$

(i) Explain the phrase *substitution reaction*.

.....

..... [1]

(ii) How do photochemical reactions differ from other reactions?

.....

..... [1]

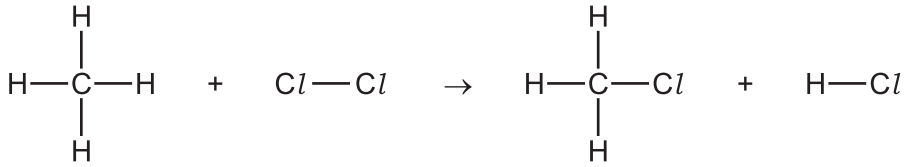
(b) Bond forming is exothermic, bond breaking is endothermic. Explain the difference between an exothermic reaction and an endothermic reaction.

.....

..... [2]

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(c) Use the bond energies to show that the following reaction is exothermic.
Bond energy is the amount of energy (kJ / mol) which must be supplied to break one mole of the bond.



Bond energies in kJ / mol

C*l*–C*l*	+242
C–C*l*	+338
C–H	+412
H–C*l*	+431

bonds broken	energy in kJ / mol
.....	.....
.....	.....
total energy =	.....

bonds formed	energy in kJ / mol
.....	.....
.....	.....
total energy =	.....

.....

..... [4]

[Total: 8]

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Bond energies Click for more variations

9 **(a)** **(i)** hydrogen (atoms) replaced by (atoms) of a different element e.g. chlorine [1]
NOT: substitute

(ii) light required [1]

(b) exothermic reaction gives out energy [1]
endothermic reaction absorbs
takes in energy [1]

(c)

bonds broken	energy
C-H	+412
C*l*-C*l*	+242
total energy	+654

[1]

bonds formed	energy
C-C*l*	–338
H-C*l*	–431
total energy	–769

[1]
energy change –115 [1]
negative sign indicates exothermic [1]

[Total: 8]

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10 Ethene is an alkene which reacts with bromine as shown in the equation.

$$C_2H_4 + Br_2 \rightarrow C_2H_4Br_2$$

(a) Write the general formula of alkenes.

..... [1]

(b) Describe the colour change seen when ethene is bubbled through aqueous bromine.

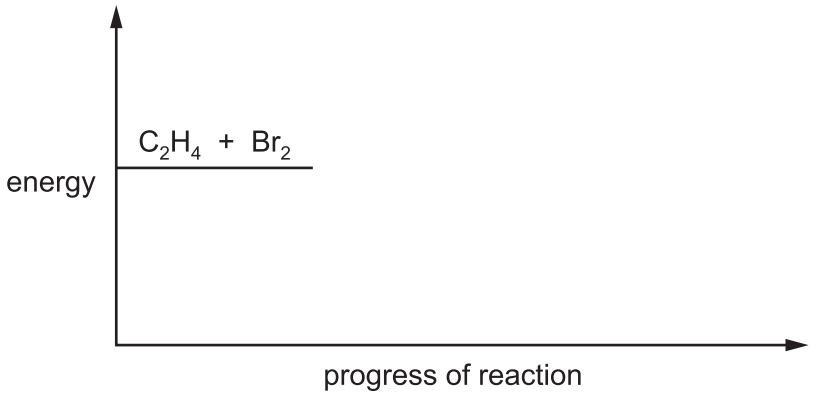
from ..... to ..... [1]

(c) In this reaction only one product is formed from two reactants.

Name this type of organic reaction.

..... [1]

(d) Part of the energy profile diagram of this reaction is shown.



(i) The reaction is exothermic.

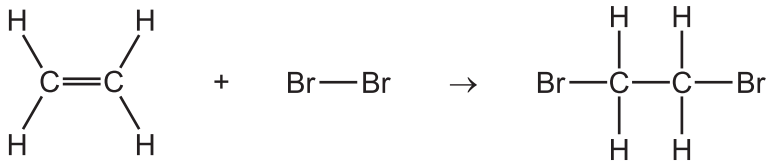
Complete the energy profile diagram for this reaction.
Include:

- the position of the products
- an arrow to show the activation energy, labelled as A
- an arrow to show the energy change for the reaction.

[3]

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(ii) The chemical equation for the reaction can be represented as shown.



Some bond energies are given.

bond	bond energy / kJ mol
C–H	410
C=C	610
Br–Br	190
C–C	350
C–Br	290

Use the bond energies in the table to calculate the energy change in this reaction.

Use the following steps.

- Calculate the energy needed to break bonds.

energy = ... kJ

- Calculate the energy released in making bonds.

energy = ... kJ

- Determine the energy change in this reaction.

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energy change in this reaction = ... kJ / mol
[3]

[Total: 9]

Exothermic and endothermic reactions Click for more variations

10(a)	C_nH_{2n}	**1**
10(b)	orange to colourless	**1**
10(c)	addition	**1**
10(d)(i)	**M1** horizontal line below energy level to right hand side of reactants line and labelled $C_2H_4Br_2$ (1) **M2** activation energy 'hump' with upward arrow **labelled A** from the reactants level (1) **M3** one downward arrow starting from the energy level of the reactants and finishing at the energy level of the products (1)	**3**
10(d)(ii)	**M1** energy needed to break bonds 4 × C–H + C=C + Br–Br = 4 × 410 + 610 + 190 = 2440 (kJ) (1) **M2** energy released in making bonds 4 × C–H + C–C + 2 × C–Br = 4 × 410 + 350 + 2 × 290 = 2570 (kJ) (1) **M3** energy change M1 – M2 = – 130 (kJ / mol) (1)	**3**

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