



IGCSE Chemistry

CHEMICAL ENERGETICS

0620-THEORY

2026 EDITION

Q1

0620/32/O/N/24/Q7(b)(iii)

1 mark

(iii) Neutralisation reactions are exothermic.

Define the term exothermic.

..... [1]

Q2

0620/31/M/J/23/Q4(c)(iii)

1 mark

(iii) Complete this sentence about an exothermic reaction using a word from the list.

products**reactants****sulfur****surroundings**

An exothermic reaction transfers thermal energy to the [1]

Q3

0620/31/O/N/25/Q8(c)

2 marks

- (c) Fig. 8.2 shows the reaction pathway diagram for the reaction of magnesium with dilute hydrochloric acid.

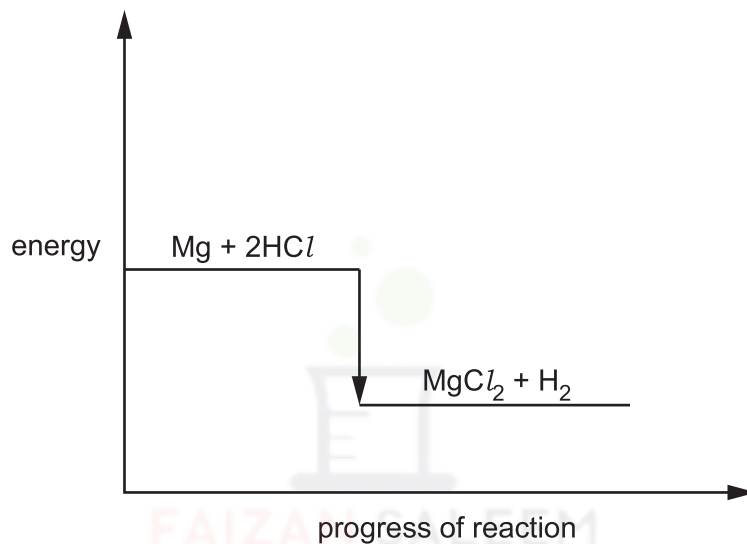


Fig. 8.2

Deduce the type of energy change shown in the diagram in Fig. 8.2.

Explain your answer.

.....

.....

.....

..... [2]

Q4

0620/31/O/N/24/Q7(b)(i)

1 mark

(b) Crystals of potassium chloride dissolve in water. This process is endothermic.

(i) Define the term endothermic.

.....
..... [1]

Q5

0620/33/M/J/23/Q4(b)(iii)

1 mark

(iii) Complete this sentence about an endothermic reaction using a word from the list.

products reactants bromine surroundings

An endothermic reaction transfers thermal energy from the [1]

Q6

0620/32/M/J/25/Q7(c)(ii)

1 mark

(c) Table 7.1 shows the results of four experiments.

Table 7.1

experiment	initial temperature / °C	final temperature / °C
1	18	23
2	19	17
3	18	14
4	19	29

(ii) State which experiment is the most endothermic.

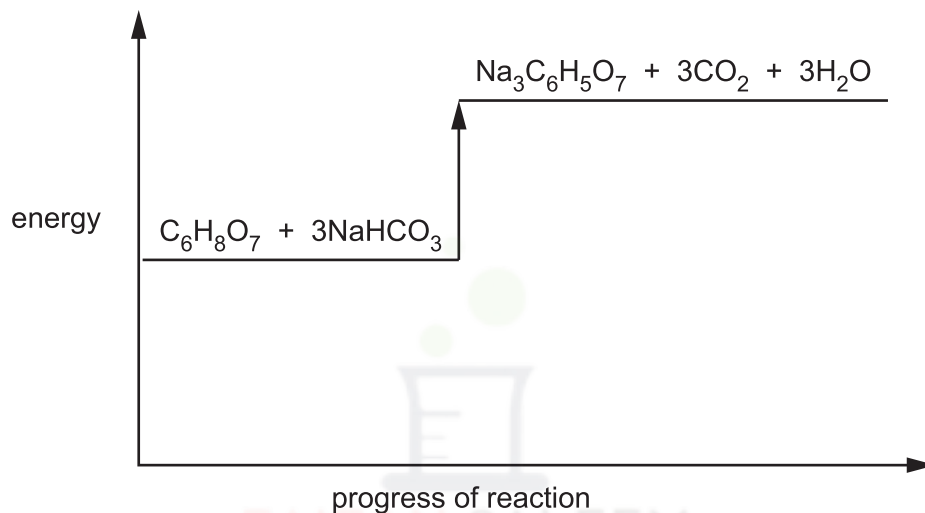
..... [1]

Q7

0620/33/O/N/25/Q8(d)

2 marks

- (d) Fig. 8.2 shows the reaction pathway diagram for the reaction of dilute citric acid with aqueous sodium hydrogencarbonate.

**Fig. 8.2**

Deduce the type of energy change shown in the diagram in Fig. 8.2.

Explain your answer.

.....

.....

.....

..... [2]

Q8

0620/42/O/N/23/Q5(a)

1 mark

5 Chemical reactions can involve transfer of thermal energy.

(a) State the term used for the transfer of thermal energy during a reaction.

..... [1]

Q9

0620/42/F/M/23/Q3(b)(i)-(ii)

2 marks

(b) The equation for the Haber process is shown.



The reaction is reversible. The forward reaction is exothermic.

(i) State what is meant by the symbol ΔH .

..... [1]

(ii) ΔH for the forward reaction is -92 kJ/mol .

State why this value shows that the forward reaction is exothermic.

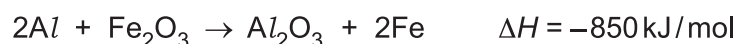
..... [1]

Q10

0620/43/O/N/25/Q3(c)(ii)

1 mark

(c) Aluminium reacts with iron(III) oxide. The equation is shown.



(ii) State what can be deduced about the reaction from the negative sign in $\Delta H = -850 \text{ kJ/mol}$.

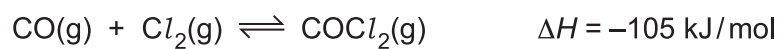
..... [1]

Q11

0620/42/F/M/25/Q4(d)

1 mark

- 4 Carbonyl chloride, COCl_2 , is manufactured by reacting carbon monoxide with chlorine.



- (d) Deduce the value of ΔH for the reverse reaction. Include a sign in your answer.

..... [1]



Q12

0620/42/O/N/23/Q5(b)(iv)-(v)

3 marks

(iv) Define the term activation energy.

.....
..... [2]

(v) State **one** way in which the activation energy of a reaction can be changed.

..... [1]

Q13

0620/42/O/N/24/Q3(e)(ii)

1 mark

(ii) Give the symbol for activation energy.

..... [1]

Q14

0620/42/M/J/23/Q5(a)(ii)

1 mark

- 5 Propane and propene both react with chlorine.
- (a) When a molecule of propane, C_3H_8 , reacts with chlorine in the presence of ultraviolet light, one atom of hydrogen is replaced by one atom of chlorine.
- (ii) State the purpose of ultraviolet light in this reaction.

..... [1]

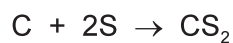


Q15

0620/32/F/M/21/Q5(c)(i)-(ii)

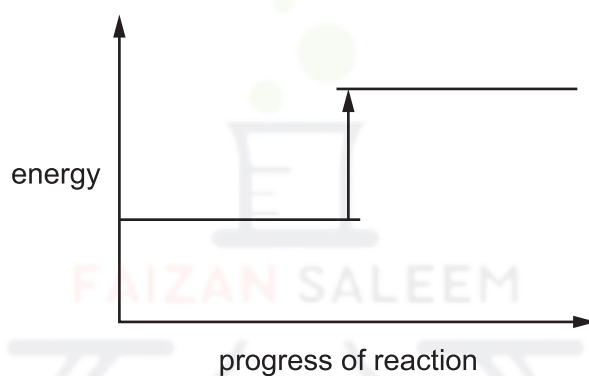
2 marks

(c) When carbon is heated with sulfur, carbon disulfide, CS_2 , is produced.



(i) Complete the energy level diagram for the production of carbon disulfide by writing these formulae on the diagram:

- $\text{C} + 2\text{S}$
- CS_2 .



[1]

(ii) Explain, using information on the energy level diagram, how you know that this reaction is endothermic.

..... [1]

Q16

0620/32/F/M/23/Q4(c)(i)-(ii)

2 marks

(c) Magnesium chloride is produced when magnesium burns in chlorine.

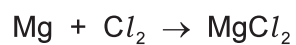


Fig. 4.1 shows an incomplete reaction pathway diagram for this reaction.

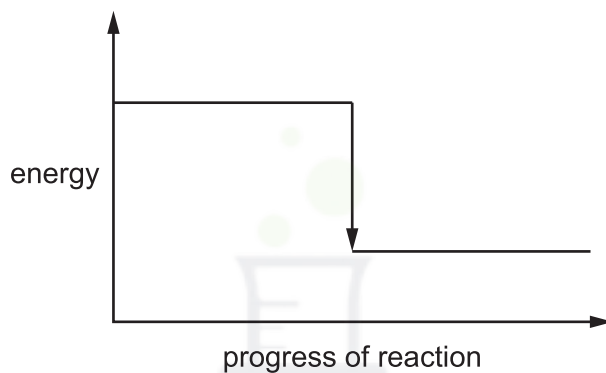


Fig. 4.1

(i) Complete Fig. 4.1 by writing these formulae on the diagram:

- $\text{Mg} + \text{Cl}_2$
- MgCl_2 .

[1]

(ii) Explain how Fig. 4.1 shows that the reaction is exothermic.

.....
..... [1]

Q17

0620/32/M/J/25/Q7(c)(iv)

2 marks

(iv) Fig. 7.1 shows an incomplete reaction pathway diagram for an endothermic reaction.

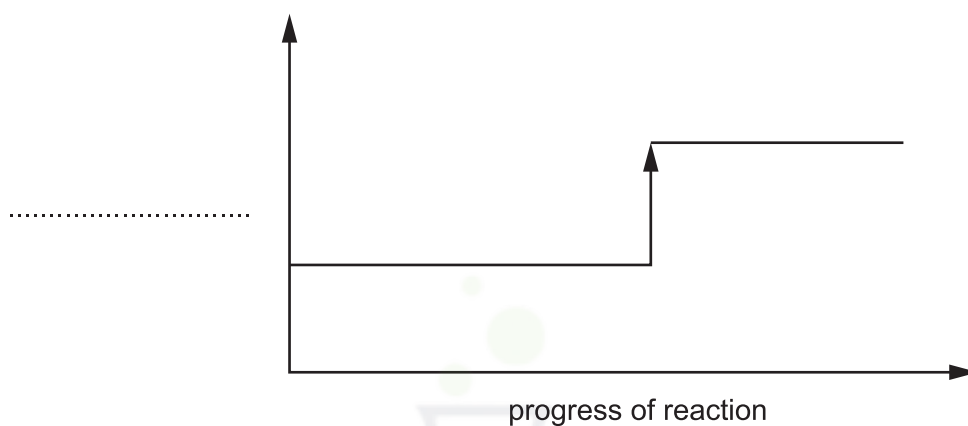


Fig. 7.1

Complete Fig. 7.1 by labelling:

- the vertical axis
- the reactants
- the products.

[2]

Q18

0620/33/M/J/25/Q6(b)(iii)

2 marks

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

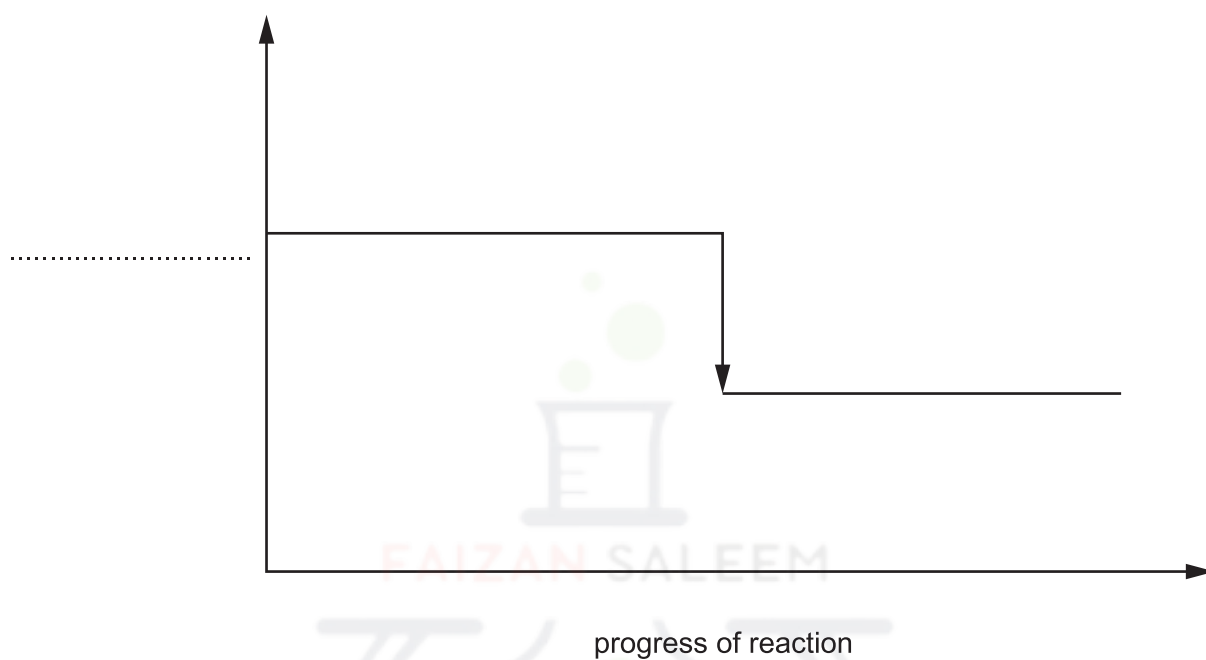


Fig. 6.1

Complete Fig. 6.1 by labelling:

- the vertical axis
- the reactants
- the products.

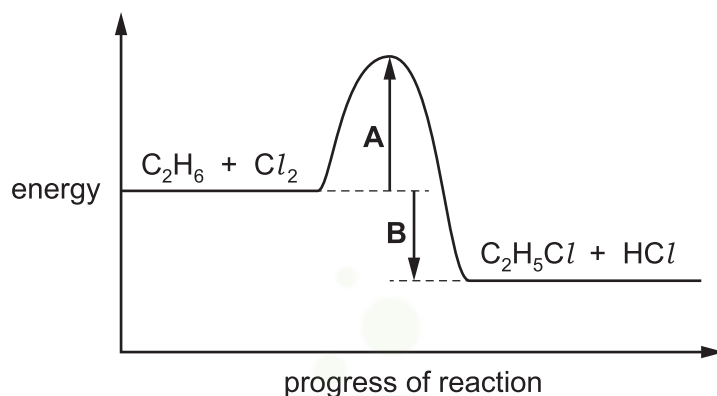
[2]

Q19

0620/42/O/N/22/Q5(e)(i)-(iii)

3 marks

(e) The energy profile diagram of this reaction is shown.



(i) Name the energy change labelled A.

..... [1]

(ii) Name the energy change labelled B.

..... [1]

(iii) State how the energy profile diagram shows this is an exothermic reaction.

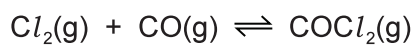
..... [1]

Q20

0620/42/O/N/21/Q4(b)(i)

3 marks

- 4 Chlorine reacts with carbon monoxide to produce phosgene gas, $\text{COCl}_2(\text{g})$. A catalyst is used.

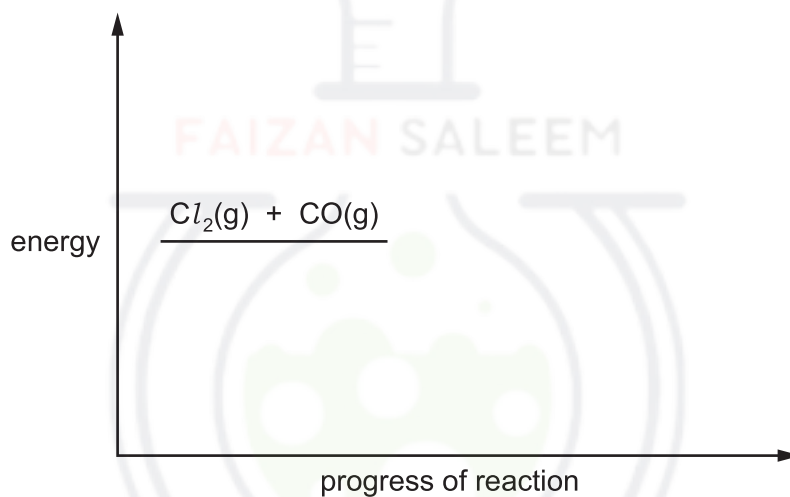


The reaction is exothermic.

- (b) (i) Complete the energy level diagram for this reaction.

On your diagram show:

- the product of the reaction
- an arrow representing the energy change, labelled ΔH
- an arrow representing the activation energy, labelled A.



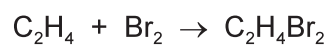
[3]

Q21

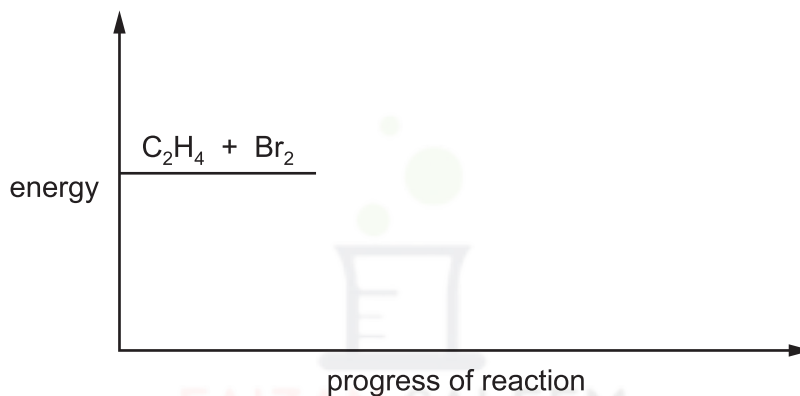
0620/41/O/N/22/Q5(d)(i)

3 marks

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



- (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]

Q22

0620/42/O/N/23/Q5(b)(iii)

3 marks

(iii) Fig. 5.1 shows an incomplete reaction pathway diagram for the forward reaction.

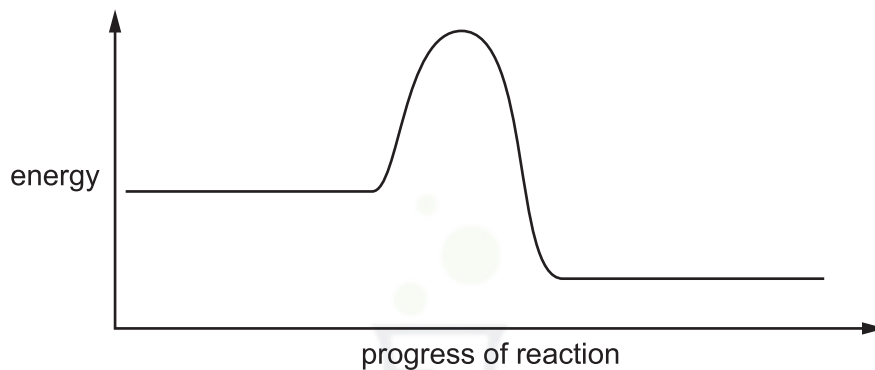
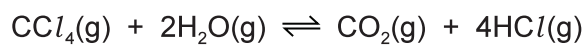


Fig. 5.1

On Fig. 5.1:

- insert the formulae of the reactants and products
- draw an arrow, labelled E_a , to show the activation energy
- draw an arrow, labelled ΔH , to show the transfer of energy in the reaction.

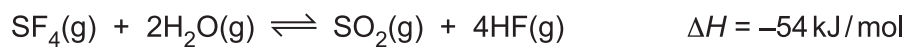
[3]

Q23

0620/41/O/N/25/Q4(a)

4 marks

- 4 Gaseous sulfur tetrafluoride, SF_4 , reacts with steam in a reversible reaction.



- (a) Complete the reaction pathway diagram in Fig. 4.1 for this reaction.

Include in your diagram:

- the position and the formulae of the products
- an arrow, labelled E_a , to show the activation energy
- an arrow, labelled ΔH , to show the enthalpy change of the reaction.

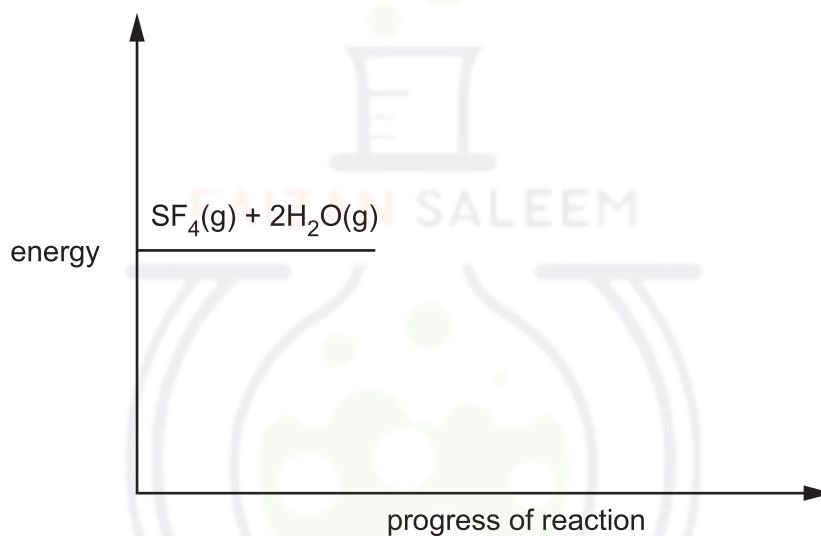


Fig. 4.1

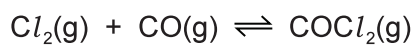
[4]

Q24

0620/42/O/N/21/Q4(a)

3 marks

- 4 Chlorine reacts with carbon monoxide to produce phosgene gas, $\text{COCl}_2(\text{g})$. A catalyst is used.



The reaction is exothermic.

- (a) Explain why the reaction is exothermic in terms of the energy changes of bond breaking and bond making.

.....

.....

..... [3]

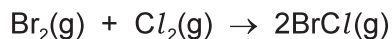


Q25

0620/41/M/J/22/Q7(e)

3 marks

- (e) Bromine monochloride, BrCl , is made by the reaction between bromine and chlorine. The chemical equation is shown.



bond	bond energy in kJ/mol
Br–Br	190
Cl–Cl	242
Br–Cl	218

Calculate the overall energy change for the reaction using bond energies.

Use the following steps.

- Calculate the total amount of energy required to break the bonds in 1 mole of $\text{Br}_2(\text{g})$ and 1 mole of $\text{Cl}_2(\text{g})$.

..... kJ

- Calculate the total amount of energy released when the bonds in 2 moles of $\text{BrCl}(\text{g})$ are formed.

..... kJ

- Calculate the overall energy change for the reaction.

..... kJ/mol
[3]

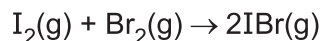
Q26

0620/41/M/J/25/Q6(d)(ii)

3 marks

- (ii) Iodine and bromine react at high temperatures to form iodine monobromide, IBr.

The equation is shown.



The structures of the molecules involved in the reaction are I–I, Br–Br and I–Br.

Table 6.1

bond	bond energy in kJ/mol
I–I	150
Br–Br	193
I–Br	175

Calculate the enthalpy change, ΔH , for the reaction using the bond energies in Table 6.1.

Use the following steps.

- Calculate the **total** amount of energy required to break the bonds in 1 mol of $\text{I}_2(\text{g})$ and 1 mol of $\text{Br}_2(\text{g})$.

..... kJ

- Calculate the total amount of energy released when the bonds in 2 mol of IBr(g) are formed.

..... kJ

- Calculate the enthalpy change, ΔH , for the reaction.
Your answer should include a sign.

..... kJ/mol
[3]

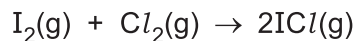
Q27

0620/43/M/J/25/Q6(e)(iii)

3 marks

(iii) Iodine and chlorine react at high temperatures to form iodine monochloride, ICl .

The equation for the reaction is shown.



The structures of the molecules involved in the reaction are $\text{I}-\text{I}$, $\text{Cl}-\text{Cl}$ and $\text{I}-\text{Cl}$.

Table 6.1

bond	bond energy in kJ/mol
$\text{I}-\text{I}$	150
$\text{Cl}-\text{Cl}$	242
$\text{I}-\text{Cl}$	218

Calculate the enthalpy change, ΔH , for the reaction using the bond energies in Table 6.1.

Use the following steps.

- Calculate the **total** amount of energy required to break the bonds in 1 mol of $\text{I}_2(\text{g})$ and 1 mol of $\text{Cl}_2(\text{g})$.

..... kJ

- Calculate the total amount of energy released when the bonds in 2 mol of $\text{ICl}(\text{g})$ are formed.

..... kJ

- Calculate the enthalpy change, ΔH , for the reaction.
Your answer should include a sign.

..... kJ/mol
[3]

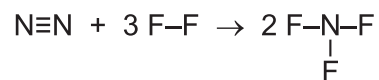
Q28

0620/42/M/J/21/Q5(b)(i)-(ii)

4 marks

(b) Nitrogen reacts with fluorine to form nitrogen trifluoride, NF_3 .

(i) The chemical equation can be represented as shown.



Some bond energies are shown in the table.

bond	bond energy in kJ/mol
$\text{N}\equiv\text{N}$	945
$\text{F}-\text{F}$	160
$\text{N}-\text{F}$	300

Calculate the energy change for the reaction between nitrogen and fluorine, using the following steps:

- energy taken in to break bonds

..... kJ

- energy released when bonds are formed

..... kJ

- energy change during the reaction.

..... kJ/mol
[3]

(ii) Use your answer to (i) to deduce whether this reaction is endothermic or exothermic. Explain your answer.

.....

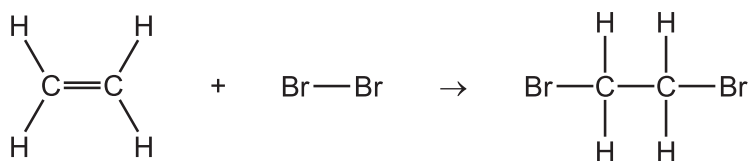
..... [1]

Q29

0620/41/O/N/22/Q5(d)(ii)

3 marks

(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.

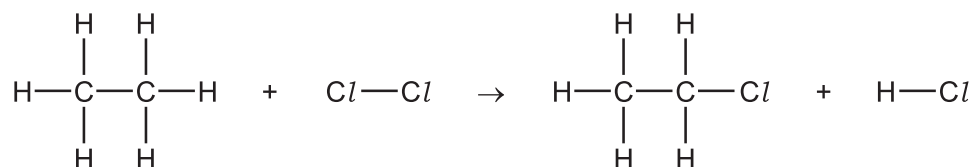
energy change in this reaction = ... kJ/mol
[3]

Q30

0620/42/O/N/22/Q5(f)

3 marks

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



Some bond energies are given.

bond	bond energy / kJ mol
C-H	410
C-C	350
Cl-Cl	240
C-Cl	340
H-Cl	430

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.

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

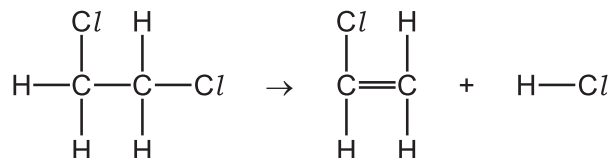
Q31

0620/43/O/N/22/Q6(a)(i)-(ii)

4 marks

- 6 (a) Chloroethene ($\text{CH}_2=\text{CHCl}$) can be manufactured from 1,2-dichloroethane ($\text{CH}_2\text{ClCH}_2\text{Cl}$).

The equation can be represented as shown.



- (i) Some bond energies are given.

bond	bond energy in kJ/mol
C—C	350
C=C	610
C—Cl	340
C—H	410
H—Cl	430

Use the bond energies in the table to calculate the energy change, in kJ/mol, of the reaction.

Use the following steps.

- Calculate the energy needed to break bonds.

energy = ... kJ

- Calculate the energy released when bonds form.

energy = ... kJ

- Calculate the energy change of the reaction.

energy change of the reaction = ... kJ/mol
[3]

- (ii) Deduce whether the energy change for this reaction is exothermic or endothermic.

Give a reason for your answer.

.....
..... [1]

Q32

0620/43/O/N/25/Q4(b)

3 marks

(b) Ethene, C_2H_4 , reacts with chlorine, Cl_2 , to form 1,2-dichloroethane, CH_2ClCH_2Cl .

The equation for this reaction can be represented as shown.

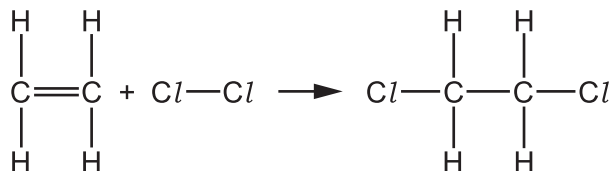


Table 4.2 shows some bond energies.

Table 4.2

bond	bond energy in kJ/mol
C—C	350
C=C	610
C—H	410
Cl—Cl	240
C—Cl	340

Use the bond energies in Table 4.2 to calculate the enthalpy change, in kJ/mol, of the reaction.

Use the following steps.

- Calculate the total energy needed to break the bonds in C_2H_4 and Cl_2 .

.....kJ

- Calculate the total energy released when the bonds form in CH_2ClCH_2Cl .

.....kJ

- Calculate the enthalpy change of the reaction.
Your answer should include a sign.

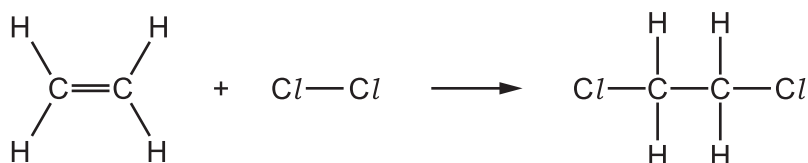
.....kJ/mol
[3]

Q33

0620/42/F/M/22/Q5(c)(ii)

4 marks

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



The energy change for the reaction is -180 kJ/mol .

Use the bond energies in the table to calculate the bond energy of a $\text{C}-\text{Cl}$ bond, in kJ/mol .

bond	$\text{C}-\text{H}$	$\text{C}=\text{C}$	$\text{Cl}-\text{Cl}$	$\text{C}-\text{C}$
bond energy in kJ/mol	410	610	240	350

Use the following steps.

step 1 Calculate the energy needed to break bonds.

energy needed to break bonds = ... kJ

step 2 Use your answer in **step 1** and the energy change for the reaction to determine the energy released when bonds are formed.

energy released when bonds form = ... kJ

step 3 Use your answer in **step 2** and bond energy values to determine the energy of a $\text{C}-\text{Cl}$ bond.

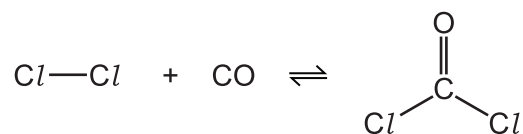
bond energy of a $\text{C}-\text{Cl}$ bond = ... kJ/mol
[4]

Q34

0620/42/O/N/21/Q4(d)

3 marks

(d) The reaction between chlorine and carbon monoxide can be represented as shown.



When one mole of chlorine reacts with one mole of carbon monoxide, 230 kJ of energy is released.

Some bond energies are shown in the table.

bond	bond energy in kJ/mol
Cl-Cl	240
C=O	745
C-Cl	400

Use the information to calculate the energy of the bond between the C and the O in carbon monoxide, CO.

bond energy in carbon monoxide, CO = ... kJ/mol [3]

Q35

0620/42/M/J/24/Q3(e)

3 marks

(e) The symbol equation for the reaction can be represented as shown in Fig. 3.1.

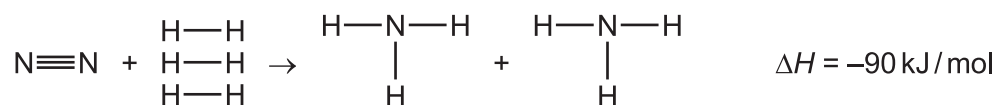


Fig. 3.1

Table 3.1 shows some bond energies.

Table 3.1

bond	$\text{N}\equiv\text{N}$	$\text{H}-\text{H}$
bond energy in kJ/mol	945	435

Use the bond energies in Table 3.1 and ΔH to calculate the bond energy of an $\text{N}-\text{H}$ bond, in kJ/mol.

Use the following steps.

- Calculate the energy needed to break bonds in the reactants.

..... kJ

- Calculate the energy released when bonds form in the products.

..... kJ

- Calculate the energy of an $\text{N}-\text{H}$ bond.

..... kJ/mol
[3]

Q36

0620/42/F/M/25/Q4(f)

3 marks

(f) The equation for the reaction can be represented as shown in Fig. 4.1.

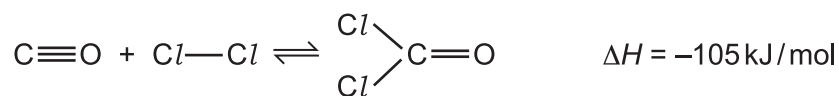


Fig. 4.1

Table 4.2 shows some bond energies.

Table 4.2

bond	$\text{C}\equiv\text{O}$	$\text{Cl}-\text{Cl}$	$\text{C}-\text{Cl}$
bond energy in kJ/mol	1075	240	340

Use the bond energies in Table 4.2 and the value of ΔH for the reaction to calculate the bond energy, in kJ/mol, of the C=O bond.

Use the following steps.

- Calculate the energy needed to break the bonds in the reactants.

..... kJ

- Calculate the energy released when the bonds in carbonyl chloride form.

..... kJ

- Calculate the bond energy of the C=O bond.

..... kJ/mol
[3]

Q37

0620/42/O/N/23/Q5(c)

4 marks

- (c) The equation for the reaction between tetrachloromethane gas and steam can be represented as shown in Fig. 5.2.

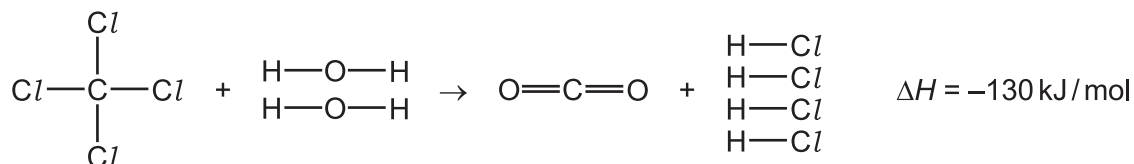


Fig. 5.2

Table 5.1 shows some bond energies.

Table 5.1

bond	C-Cl	H-O	C=O
bond energy in kJ/mol	340	460	805

Use the bond energies in Table 5.1 and the ΔH value for the reaction to calculate the H-Cl bond energy using the following steps.

- Calculate the energy needed to break the bonds in the reactants.

..... kJ

- Calculate the energy released when the bonds in carbon dioxide form.

..... kJ

- Calculate the H-Cl bond energy.

..... kJ/mol
[4]

Q38

0620/41/O/N/25/Q4(b)

4 marks

(b) The equation for the reaction can be represented as shown in Fig. 4.2.

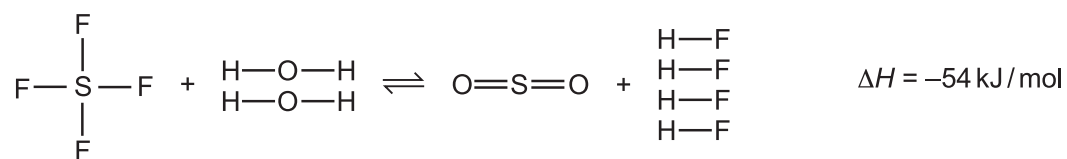


Fig. 4.2

Table 4.1 shows some bond energies.

Table 4.1

bond	S-F	O-H	H-F
bond energy in kJ/mol	330	460	570

Use the bond energies in Table 4.1 and the value of ΔH of the reaction to calculate the S=O bond energy in kJ/mol.

Use the following steps.

- Calculate the energy needed to break the bonds in the reactants.

..... kJ

- Calculate the energy released when the bonds in the products form.

..... kJ

- Calculate the S=O bond energy.

..... kJ/mol
[4]

Q39

0620/62/F/M/25/Q2(a), Q2(d)

5 marks

- 2 A student investigates the temperature change when aqueous copper(II) sulfate reacts separately with two different metals, zinc and iron.

The student does two experiments.

- (a) Complete Table 2.1 by using the thermometer diagrams and calculating the temperature changes from the temperature at 0 s.

Table 2.1

time in s	Experiment 1			Experiment 2		
	thermometer diagram	temperature in °C	temperature change since time = 0 s in °C	thermometer diagram	temperature in °C	temperature change since time = 0 s in °C
0		24.0	0.0		22.0	0.0
30						
60						
90						
120						
150						
180						
210						

[4]

Q39 continued

0620/62/F/M/25/Q2(a), Q2(d)

5 total

- (d) State which experiment, Experiment 1 or Experiment 2, is the more exothermic. Explain your answer.

more exothermic experiment

explanation

..... [1]

Q40

0620/63/M/J/23/Q2(a), Q2(c)-(d)

6 marks

- 2 A student investigates the temperature change when solid citric acid reacts with solid sodium carbonate.

The student does six experiments.

(a) Experiment 1

- Place 5.0 g of solid sodium carbonate in a 100 cm³ beaker.
- Use a thermometer to stir the solid sodium carbonate for 30 seconds. Measure the temperature of the solid sodium carbonate.

Experiment 2

- Add 1.0 g of solid citric acid to the solid sodium carbonate in the beaker from Experiment 1.
- Use the thermometer to stir the mixture for 30 seconds. Measure the temperature of the mixture.
- Rinse the beaker and thermometer with water.

Experiment 3

- Place 5.0 g of solid sodium carbonate in the 100 cm³ beaker.
- Add 2.0 g of solid citric acid to the solid sodium carbonate in the beaker.
- Use the thermometer to stir the mixture for 30 seconds. Measure the temperature of the mixture.
- Rinse the beaker and thermometer with water.

Experiment 4

- Repeat Experiment 3, using 4.0 g of solid citric acid instead of 2.0 g.

Experiment 5

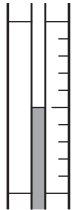
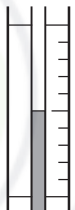
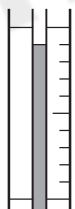
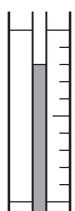
- Repeat Experiment 4, using 5.0 g of solid citric acid instead of 4.0 g.

Experiment 6

- Repeat Experiment 5, using 6.0 g of solid citric acid instead of 5.0 g.

Use the information in the description of the experiments and the thermometer diagrams to complete Table 2.1.

Table 2.1

experiment	mass of solid sodium carbonate/g	mass of solid citric acid/g	thermometer diagram after 30 seconds	temperature after 30 seconds /°C
1	5.0	0.0		
2	5.0	1.0		
3				
4				
5				
6				

[4]

- (c) State whether the reaction between solid sodium carbonate and solid citric acid is exothermic or endothermic.
Explain your answer.

.....

..... [1]

- (d) Deduce which experiment had the greatest temperature change compared to the temperature in Experiment 1.

..... [1]



Q41

0620/63/O/N/24/Q2(a)-(d)

12 marks

- 2 A student investigates the temperature change when solid **P** dissolves in water.

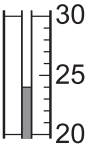
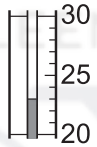
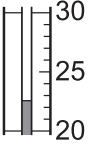
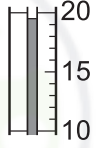
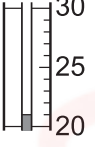
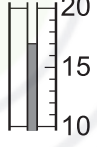
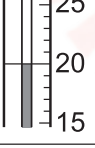
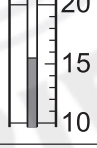
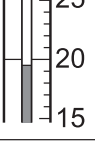
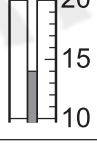
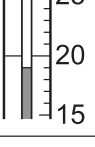
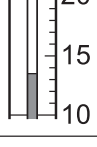
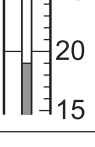
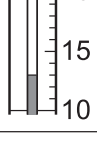
The student does two experiments.

- (a) Complete Table 2.1 by using the thermometer diagrams and calculating the temperature decreases from the temperature at 0 seconds.

For example, at 60 seconds:

$$\text{temperature decrease} = \text{temperature at 0 s} - \text{temperature at 60 s}$$

Table 2.1

time /s	Experiment 1			Experiment 2		
	thermometer diagram	temperature /°C	temperature decrease /°C	thermometer diagram	temperature /°C	temperature decrease /°C
0		24.0	0.0		23.0	0.0
20						
40						
60						
80						
100						
120						

[5]

- (b) Complete a suitable scale on the y-axis and plot the results from Experiment 1 and Experiment 2 on Fig. 2.1.

Draw **two** lines of best fit. Both of your lines of best fit **must** go to (0,0). Label both lines.

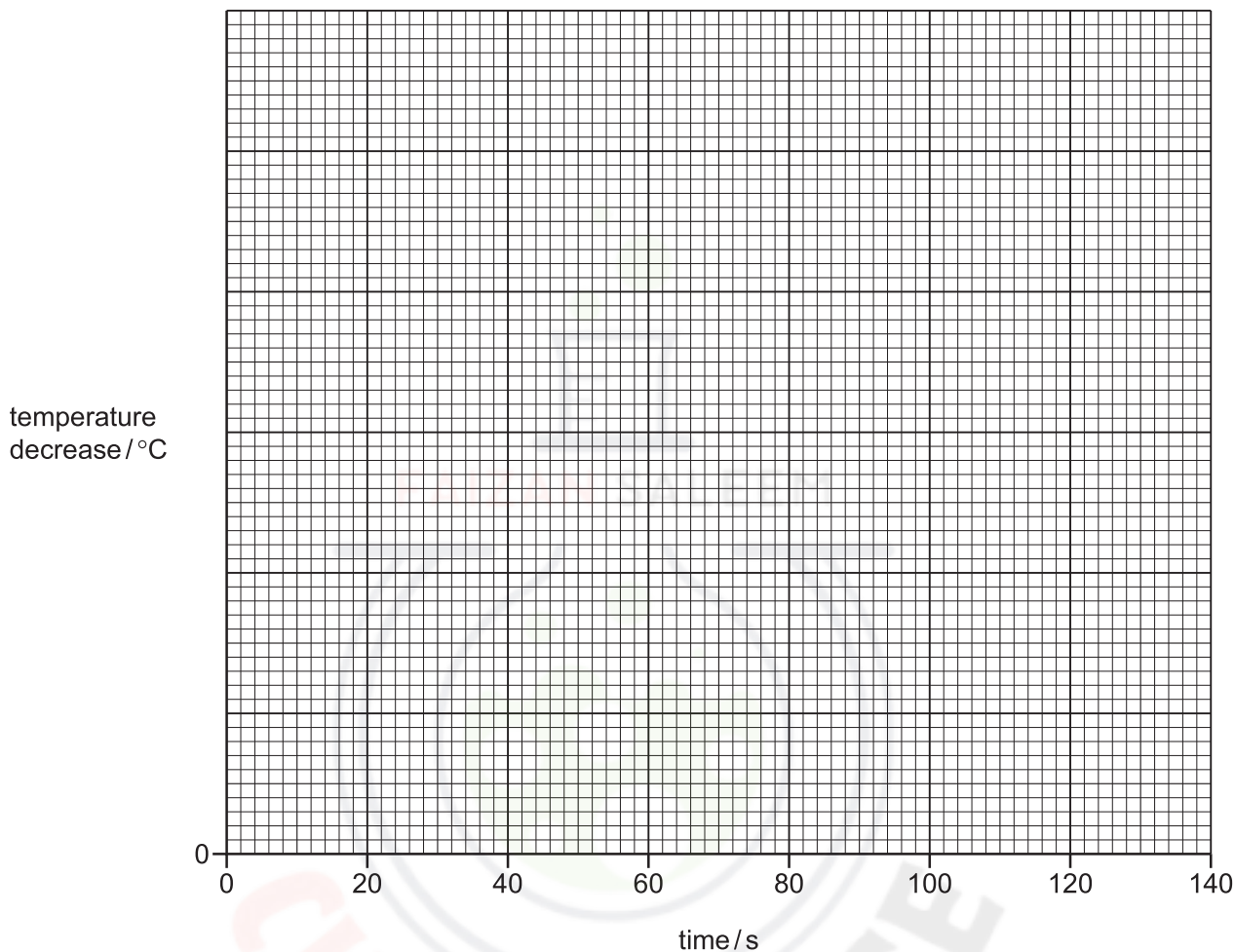


Fig. 2.1

[4]

- (c) State whether the energy change in Experiment 1 is exothermic or endothermic. Explain your answer.

.....
..... [1]

- (d) Compare the maximum temperature decrease in Experiment 1 with the maximum temperature decrease in Experiment 2.

.....
.....
..... [2]

Q42

0620/61/M/J/21/Q2(e)

4 marks

- 2 A student investigated the temperature decrease when sodium hydrogencarbonate reacts with dilute hydrochloric acid.

The student did six experiments.

Experiment 1

- Using a measuring cylinder, 25 cm³ of dilute hydrochloric acid was poured into a conical flask.
- The initial temperature of the acid was measured using a thermometer.
- 1 g of sodium hydrogencarbonate was added to the conical flask. At the same time a stop-clock was started.
- The acid and sodium hydrogencarbonate mixture in the conical flask was stirred continuously using the thermometer.
- The temperature of the mixture after 1 minute was measured.
- The conical flask was rinsed with distilled water.

- (e) Suggest **two** changes that could be made to the apparatus that would improve the accuracy of the results. For each change explain why it would improve the accuracy of the results.

change 1

explanation 1

.....

change 2

explanation 2

.....

[4]

Q43

0620/62/O/N/22/Q2(f)

2 marks

- 2 A student investigated the temperature change when two different aqueous solutions of sodium hydroxide, solution **G** and solution **H**, reacted with dilute hydrochloric acid.

Two experiments were done.

(a) *Experiment 1*

- A burette was rinsed with distilled water and then with dilute hydrochloric acid.
- The burette was filled with the dilute hydrochloric acid. The hydrochloric acid was then run out through the tap until the level was on the 0.00 cm^3 mark.
- A 50 cm^3 measuring cylinder was used to pour 20 cm^3 of solution **G** into a beaker.
- A thermometer was used to measure the initial temperature of solution **G**.
- 5 cm^3 of dilute hydrochloric acid was added from the burette into the beaker.
- The mixture in the beaker was stirred using the thermometer and the temperature of the mixture was measured.
- Another 5 cm^3 of dilute hydrochloric acid was added from the burette into the beaker.
- The mixture in the beaker was stirred using the thermometer and the temperature of the mixture was measured.
- 5 cm^3 portions of dilute hydrochloric acid continued to be added and the temperature measured until a total of 35 cm^3 of dilute hydrochloric acid had been added.

Experiment 2

- Experiment 1 was repeated using solution **H** instead of solution **G**.

- (f) Explain how the results obtained would be different if a polystyrene cup is used instead of the beaker.

.....

.....

.....

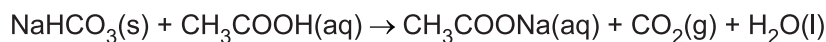
..... [2]

Q44

0620/61/M/J/25/Q4

6 marks

- 4 Solid sodium hydrogencarbonate, NaHCO_3 , reacts with dilute hydrochloric acid and with dilute ethanoic acid.



These two reactions are endothermic.

Plan an investigation to find which of the two reactions is the most endothermic. Your plan must include how you can use the results to find which reaction is the most endothermic.

You are provided with solid sodium hydrogencarbonate, dilute hydrochloric acid, dilute ethanoic acid and common laboratory apparatus.

FAIZAN SALEEM



CHEM BRIDGE

... [6]

Q45

0620/61/O/N/25/Q4

6 marks

- 4** When a solid metal is added to an aqueous salt of a less reactive metal, a reaction takes place. The reaction is exothermic, and the temperature of the reaction mixture increases. The larger the difference in reactivity of the two metals, the more exothermic the reaction.

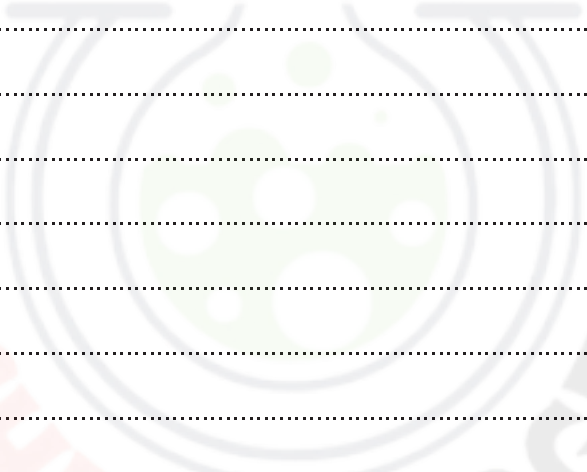
Cobalt, manganese and nickel are three metals which are all more reactive than copper and react with aqueous copper(II) sulfate. The temperature of the reaction mixture increases during each reaction.

Plan an investigation to find the order of reactivity of the three metals cobalt, manganese and nickel.

Your plan should include how you can use the results to find the order of reactivity of the three metals cobalt, manganese and nickel.

You are provided with powdered samples of cobalt, manganese and nickel, aqueous copper(II) sulfate and common laboratory apparatus.

FAIZAN SALEEM



CHEM BRIDGE

... [6]

Q1 0620/32/O/N/24/Q7(b)(iii)

1 mark

7(b)(iii)	release of thermal energy	1
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Q2 0620/31/M/J/23/Q4(c)(iii)

1 mark

4(c)(iii)	surroundings	1
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Q3 0620/31/O/N/25/Q8(c)

2 marks

8(c)(i)	exothermic (1) energy level of products below that of reactants (1)	2
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Source label note: the question paper labels this Q8(c); the published marking scheme labels it 8(c)(i).

Q4 0620/31/O/N/24/Q7(b)(i)

1 mark

7(b)(i)	absorption of thermal energy	1
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Q5 0620/33/M/J/23/Q4(b)(iii)

1 mark

4(b)(iii)	surroundings	1
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Q6 0620/32/M/J/25/Q7(c)(ii)

1 mark

7(c)(ii)	(experiment) 3	1
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Q7 0620/33/O/N/25/Q8(d)

2 marks

8(d)(i)	endothermic (1) energy (level) of products above that of reactants (1) OR A	2
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Source label note: the question paper labels this Q8(d); the published marking scheme labels it 8(d)(i).

Q8 **0620/42/O/N/23/Q5(a)** 1 mark

5(a)	enthalpy change (of reaction)	1
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Q9 **0620/42/F/M/23/Q3(b)(i)-(ii)** 2 marks

3(b)(i)	enthalpy change	1
3(b)(ii)	(the value of) ΔH is negative	1

Q10 **0620/43/O/N/25/Q3(c)(ii)** 1 mark

3(c)(ii)	(forward) reaction is exothermic	1
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Q11 **0620/42/F/M/25/Q4(d)** 1 mark

4(d)	+105 (kJ / mol)	1
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Q12 **0620/42/O/N/23/Q5(b)(iv)-(v)** 3 marks

5(b)(iv)	M1 minimum energy (1) M2 that colliding particles must have to react (1)	2
5(b)(v)	(decreased by adding) catalyst	1

Q13 **0620/42/O/N/24/Q3(e)(ii)** 1 mark

3(e)(ii)	E_a	1
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Q14 **0620/42/M/J/23/Q5(a)(ii)** 1 mark

5(a)(ii)	provide activation energy	1
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Q15 **0620/32/F/M/21/Q5(c)(i)-(ii)** 2 marks

5(c)(i)	C + (2)S on lower line to left AND CS ₂ on upper line to right (1)	1
5(c)(ii)	the product energy level is above the reactant energy level	1

Q16 **0620/32/F/M/23/Q4(c)(i)-(ii)** 2 marks

4(c)(i)	Mg + Cl ₂ on line on left AND MgCl ₂ on line on right	1
4(c)(ii)	the energy of the reactants is greater than the energy of the products / the energy of the products is less than the energy of the reactants	1

Q17 **0620/32/M/J/25/Q7(c)(iv)** 2 marks

7(c)(iv)	energy (on the y-axis) (1) reactants on left hand line and products on right hand line on the graph (1)	2
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Q18 **0620/33/M/J/25/Q6(b)(iii)** 2 marks

6(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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Q19 **0620/42/O/N/22/Q5(e)(i)-(iii)** 3 marks

5(e)(i)	activation energy	1
5(e)(ii)	energy (change) of reaction	1
5(e)(iii)	energy of products is lower than energy of reactants	1

Q20 **0620/42/O/N/21/Q4(b)(i)** 3 marks

4(b)(i)	M1 exothermic mark horizontal line below energy level to R.H.S. of reactants line and labelled COCl₂(g) (1) M2 activation E mark activation energy 'hump' with upward arrow labelled A / activation energy (1) M3 energy change mark one downward arrow labelled ΔH and energy change starting from E level of reactants and finishing at E level of products (1)	3
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Q21 **0620/41/O/N/22/Q5(d)(i)** 3 marks

5(d)(i)	M1 horizontal line below energy level to right hand side of reactants line and labelled C₂H₄Br₂ (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
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Q22 **0620/42/O/N/23/Q5(b)(iii)** 3 marks

5(b)(iii)	M1 Labels mark $\text{CCl}_4(\text{g}) + 2\text{H}_2\text{O}(\text{g})$ on reactant line AND $\text{CO}_2(\text{g}) + 4\text{HCl}(\text{g})$ on product line M2 Activation E mark upward arrow labelled E_a from energy level of reactants to top of 'hump' M3 Energy change mark one downward arrow labelled ΔH AND energy change starting from E level of reactants and finishing at E level of products	3
-----------	---	----------

Q23 **0620/41/O/N/25/Q4(a)** 4 marks

4(a)	M1 energy level of products below energy level of reactants M2 label of $\text{SO}_2(\text{g}) + 4\text{HF}(\text{g})$ on product line M3 upward arrow labelled E_a from energy level of reactants to the highest point of the curve M4 one downward arrow labelled ΔH AND energy change starting from energy level of reactants and finishing at energy level of products	4
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Q24 **0620/42/O/N/21/Q4(a)** 3 marks

4(a)	M1 E of making bonds > breaking bonds M2 bond making releases energy M3 bond breaking requires energy	3
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Q25 **0620/41/M/J/22/Q7(e)** 3 marks

7(e)	432(1) 436(1) – 4(1)	3
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Q26 **0620/41/M/J/25/Q6(d)(ii)** 3 marks

6(d)(ii)	M1 343 M2 350 M3 –7	3
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Q27

0620/43/M/J/25/Q6(e)(iii)

3 marks

6(e)(iii)	M1 energy required in breaking bonds $= 150 + 242 = (+) \text{ 392}$ M2 energy released when bonds are formed $= 2 \times 218 = (+) \text{ 436}$ M3 enthalpy change, ΔH $= 392 - 436 = - \text{ 44}$	3
-----------	--	----------

Q28

0620/42/M/J/21/Q5(b)(i)-(ii)

4 marks

5(b)(i)	bonds broken $[945 + (3 \times 160)] = 1425$ (1) bonds formed $(2 \times 3 \times 300) = 1800$ (1) energy change = $M1 - M2 = 1425 - 1800 = -375$ (1)	3
5(b)(ii)	<i>Answer must reflect answer in 5(b)(i)</i> exothermic and more energy released (in bond formation) than used/taken in (in bond breaking)	1

Q29

0620/41/O/N/22/Q5(d)(ii)

3 marks

5(d)(ii)	M1 energy needed to break bonds $4 \times \text{C-H} + \text{C}=\text{C} + \text{Br-Br} = 4 \times 410 + 610 + 190 = 2440$ (kJ) (1) M2 energy released in making bonds $4 \times \text{C-H} + \text{C-C} + 2 \times \text{C-Br} = 4 \times 410 + 350 + 2 \times 290 = 2570$ (kJ) (1) M3 energy change $M1 - M2 = -130$ (kJ / mol) (1)	3
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Q30

0620/42/O/N/22/Q5(f)

3 marks

5(f)	M1 energy needed to break bonds $6 \times \text{C-H} + \text{C-C} + \text{Cl-Cl} = 6 \times 410 + 350 + 240 = 3050$ (kJ / mol) (1) M2 energy released in making bonds $5 \times \text{C-H} + \text{C-C} + \text{C-Cl} + \text{H-Cl} = 5 \times 410 + 350 + 340 + 430 = 3170$ (kJ / mol) (1) M3 energy change $M1 - M2 = -120$ (kJ / mol) (1)	3
------	---	----------

Q31 **0620/43/O/N/22/Q6(a)(i)-(ii)** 4 marks

6(a)(i)	M1 2670 (1) M2 2610 (1) M3 (+) 60 (1)	3
6(a)(ii)	endothermic AND energy released when bonds form is less than energy absorbed to break bonds OR endothermic AND overall energy change has a positive sign	1

Q32 **0620/43/O/N/25/Q4(b)** 3 marks

4(b)	USUAL METHOD M1 2490 M2 2670 M3 -180 ALTERNATIVE METHOD M1 850 M2 1030 M3 -180	3
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Q33 **0620/42/F/M/22/Q5(c)(ii)** 4 marks

5(c)(ii)	M1 Bond energy in breaking bonds $= [(4 \times 410) + 610 + 240] = 2490 \text{ (kJ / mol)}$ M2 Use of total E change to find bond energy of $\text{C}_2\text{H}_4\text{Cl}_2$ $= \text{M1} + 180 = 2490 + 180 = 2670 \text{ (kJ / mol)}$ M3 Determination of total C–Cl bond energy $= \text{M2} - [(4 \times 410) + 350] = 2670 - 1990 = 680 \text{ (kJ / mol)}$ M4 Determination of each C–Cl bond energy $= \text{M3} / 2 = 680 / 2 = 340 \text{ (kJ / mol)}$	4
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Q34 **0620/42/O/N/21/Q4(d)** 3 marks

4(d)	M1 bond energy in making bonds $= [(2 \times 400) + 745] = 1545 \text{ (kJ mol}^{-1}\text{)}$ M2 use of total E change $-230 = [240 + \text{E}(\text{C}\equiv\text{O})] - 1545$ OR $[240 + \text{E}(\text{C}\equiv\text{O})] = -230 + 1545 = (+1315)$ M3 $\text{E}(\text{C}\equiv\text{O})$ $= [-230 + 1545] - 240 = 1075 \text{ (kJ mol}^{-1}\text{)}$	3
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Q35 **0620/42/M/J/24/Q3(e)** 3 marks

3(e)	M1 bond energy in breaking bonds $= [945 + (3 \times 435)] = (+) \text{ 2250 (kJ / mol)}$ M2 $= 2250 + 90 = \text{2340}$ M3 $= 2340 / 6 = \text{390}$	3
------	---	----------

Q36 **0620/42/F/M/25/Q4(f)** 3 marks

4(f)	M1 Bond energy in breaking bonds $= 1075 + 240 = (+) \text{ 1315}$ M2 Bond energy of $\text{COCl}_2 = 1315 - (-105) = 1420$ M3 $\text{C}=\text{O} = 1420 - 2 \times \text{C}-\text{Cl}$ $= 1420 - (2 \times 340) = (+) \text{ 740}$	3
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Q37 **0620/42/O/N/23/Q5(c)** 4 marks

5(c)	<i>energy needed to break bonds in reactants</i> M1 $[(4 \times 340) + (4 \times 460)] = \text{3200 (kJ / mol)}$ (1) <i>energy released when bond in carbon dioxide form</i> M2 $2 \times 805 = \text{1610 (kJ / mol)}$ (1) <i>calculate H-Cl bond energy</i> M3 $3200 - (1610 + E(4\text{H}-\text{Cl})) = -130$ $E(4\text{H}-\text{Cl}) = 3330 - 1610 = \text{1720 (kJ / mol)}$ (1) M4 $1720 / 4 = \text{430 (kJ / mol)}$ (1)	4
------	---	----------

Q38 **0620/41/O/N/25/Q4(b)** 4 marks

4(b)	M1 $= (4 \times \text{S}-\text{F}) + (4 \times \text{O}-\text{H}) = (4 \times 330) + (4 \times 460) = 3160$ M2 bond energy of products $- 3160 = -54$ $= 3160 - (-54) = 3214$ M3 $(2 \times \text{S}=\text{O}) + (4 \times \text{H}-\text{F}) = 3214$ therefore $2 \times \text{S}=\text{O} = 3214 - (4 \times 570) = 934$ M4 $\text{S}=\text{O} = \text{M3} \div 2 = 934 \div 2 = 467$	4
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Source correction: M2 should read $3160 - E(\text{products}) = -54$, so $E(\text{products}) = 3214 \text{ kJ}$. The final answer remains 467 kJ/mol .

Q39

0620/62/F/M/25/Q2(a), Q2(d)

5 marks

2(a)	M1 all 7 temperatures correct for experiment 1 (33.5, 38.0, 41.5, 43.0, 44.0, 43.0, 42.0)	1
	M2 all 7 temperatures correct for experiment 2 (24.0, 25.5, 27.0, 28.0, 28.5, 29.0, 29.0)	1
	M3 all temperature changes correct (9.5, 14.0, 17.5, 19.0, 20.0, 19.0, 18.0) (2.0, 3.5, 5.0, 6.0, 6.5, 7.0, 7.0)	1
	M4 all temperatures and temperature changes are recorded to 1 dp	1
2(d)	experiment 1 / zinc and greater temperature change / increase	1

Q40

0620/63/M/J/23/Q2(a), Q2(c)-(d)

6 marks

2(a)	M1 all masses of sodium carbonate and citric acid correct (5.0, 5.0, 5.0, 5.0, 5.0 and 1.0, 2.0, 4.0, 5.0, 6.0)	1
	M2 and M3 all temperatures correct (25.0; 11.5; 5.0; 0.5; -1.0; -2.0)	2
	M4 all values shown to 1 dp	1
2(c)	endothermic and because the temperature decreased	1
2(d)	experiment 6	1

Q41

0620/63/O/N/24/Q2(a)-(d)

12 marks

2(a)	M1 all six temperatures for Experiment 1 correct (22.5, 21.0, 20.0, 19.5, 19.0, 19.0) M2 all six temperature decreases for experiment 1 correct (1.5, 3.0, 4.0, 4.5, 5.0, 5.0) M3 all six temperatures for Experiment 2 correct (19.5, 17.0, 15.5, 14.0, 13.5, 13.0) M4 all six temperature decreases for Experiment 2 correct (3.5, 6.0, 7.5, 9.0, 9.5, 10.0) M5 all temperatures and temperature changes are recorded to 1dp	5
2(b)	M1 suitable scale on y-axis M2 and M3 all points plotted correctly M4 best-fit curves AND at least one line labelled	4
2(c)	endothermic AND temperature decreases	1
2(d)	M1 maximum temperature change / decrease is greater in Experiment 2 M2 quantitative answer (e.g. 2 times greater in Experiment 2)	2

Q42 **0620/61/M/J/21/Q2(e)** 4 marks

2(e)	change: use a pipette	1
	explanation: more accurate than a measuring cylinder	1
	change: use a polystyrene / styrofoam cup	1
	explanation: insulator / reduces heat gain	1

Q43 **0620/62/O/N/22/Q2(f)** 2 marks

2(f)	M1 temperature (changes) higher	1
	M2 as less heat lost / polystyrene is a (better) insulator	1

Q44 **0620/61/M/J/25/Q4** 6 marks

4	any 6 from MP1 known / specified mass of sodium hydrogencarbonate MP2 known / specified volume (and concentration) of hydrochloric or ethanoic acid MP3 use of a named suitable container for the reaction and named suitable apparatus to measure volume of acid MP4 measure temperature of acid before mixing MP5 add reagents together and mix / stir MP6 measure temperature of mixture / acid after mixing / reaction MP7 biggest temperature decrease is most endothermic max 6	6
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Q45 **0620/61/O/N/25/Q4** 6 marks

4	any six from: MP1 use a specified/known volume of aqueous copper(II) sulfate MP2 use of a (volumetric) pipette / measuring cylinder / burette to measure volume of solution MP3 measure initial temperature of aqueous copper(II) sulfate MP4 known / specified mass of one of the metals MP5 add metal to aqueous copper(II) sulfate and stir / mix MP6 measure highest temperature (reached) MP7 biggest temperature rise is most reactive / lowest temperature rise is least reactive	6
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