

1. Burning fuels is an exothermic reaction. What is meant by the term exothermic?

- A. A gas is produced.
- B. Energy is released.
- C. Heat is absorbed.
- D. The mass of the fuel decreases.

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.

3. Group I metals react vigorously with water and release heat. Which statement about this reaction is correct?

- A. The reaction is endothermic and the energy change is negative. *enthalpy change,  $\Delta H$*
- B. The reaction is endothermic and the energy change is positive.
- C. The reaction is exothermic and the energy change is negative.
- D. The reaction is exothermic and the energy change is positive.

CORRECTION

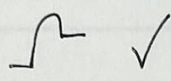

4. Plant cells use energy from sunlight for photosynthesis.  
Which row describes and explains the energy change that occurs?

	type of energy change	explanation
<b>A</b>	endothermic ✓	less energy is released making bonds than is absorbed to break bonds ✓
<b>B</b>	endothermic ✓	more energy is released making bonds than is absorbed to break bonds
<b>C</b>	exothermic	less energy is released making bonds than is absorbed to break bonds
<b>D</b>	exothermic	more energy is released making bonds than is absorbed to break bonds

5. Information about two reactions is given.

- The neutralisation reaction between citric acid and sodium hydrogencarbonate is endothermic.
- The displacement reaction between magnesium and carbon dioxide is exothermic.

Which statements about the two reactions are correct?

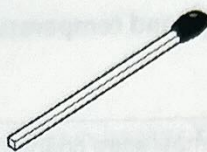
- 1 The energy of the products formed in the neutralisation reaction is greater than the energy of the reactants.  ✓
- 2 The energy of magnesium and carbon dioxide is greater than the energy of magnesium oxide and carbon.  ✓
- 3 In an exothermic reaction, the energy required to break the bonds is greater than the energy released when the new bonds are formed. ✗

- A. 1, 2 and 3
- B. 1 and 2 only**
- C. 1 and 3 only
- D. 2 and 3 only

CORRECTION	



6. The diagram shows a match.



By striking the match, a chemical reaction takes place. Which row describes the chemical reaction?

	type of reaction	reason
A	endothermic	because energy is given out as the match burns
B	endothermic	because energy is used to strike the match
C	exothermic ✓	because energy is given out as the match burns ✓
D	exothermic ✓	because energy is used to strike the match

7. Equal volumes and concentrations of dilute hydrochloric acid and aqueous sodium hydroxide are mixed. The temperatures of the solutions are shown.

solution	temperature / °C
dilute hydrochloric acid	26
aqueous sodium hydroxide	26
mixture of dilute hydrochloric acid and aqueous sodium hydroxide	33

Which statement describes the reaction?

- A. Energy is released and the products have less energy than the reactants. ✓
- B. Energy is released and the products have more energy than the reactants.
- C. Energy is absorbed and the products have less energy than the reactants.
- D. Energy is absorbed and the products have more energy than the reactants.

CORRECTION



8. Dissolving ammonium chloride in water is an endothermic change.

Which row shows the energy change and temperature change of the mixture during the dissolving of ammonium chloride?

	energy change	temperature change
<b>A</b>	energy is absorbed ✓	decrease ✓
<b>B</b>	energy is absorbed	increase
<b>C</b>	energy is released	decrease ✓
<b>D</b>	energy is released	increase

9. 10 g of ammonium nitrate is added to water at 25 °C and the mixture stirred.

The ammonium nitrate dissolves and, after one minute, the temperature of the solution is 10 °C.

Which word describes this change?

- A.** endothermic
- B.** exothermic
- C.** neutralisation
- D.** reduction

CORRECTION

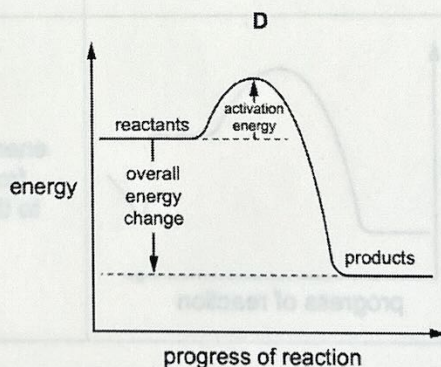
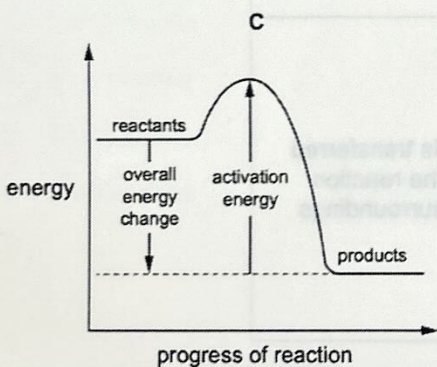
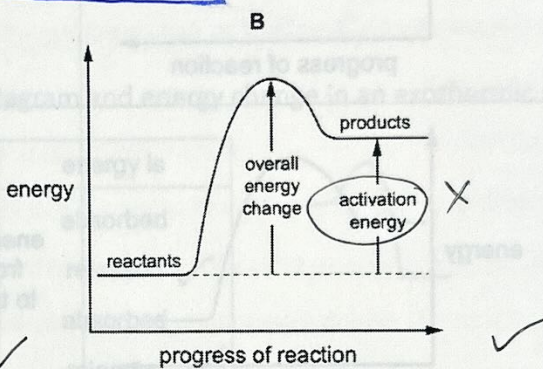
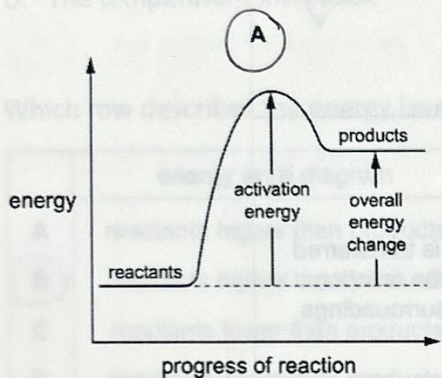


10. The temperature of the water in two beakers, X and Y, is measured as 21.5 °C.  
 5 g of sodium chloride is dissolved in the water in beaker X. The temperature changes to 18.0 °C.  $\downarrow$  *endo*  
 5 g of calcium oxide is dissolved in the water in beaker Y. The temperature changes to 29.4 °C.  $\uparrow$  *exo*  
 Which types of process are occurring in beakers X and Y?

	X	Y
A	endothermic	endothermic
<b>B</b>	endothermic	exothermic
C	exothermic	endothermic
D	exothermic	exothermic

*reaction pathway diagram*

11. Which diagram is a correctly labelled energy level diagram for an endothermic reaction?



CORRECTION

CORRECTION



12. Which row describes an endothermic reaction?

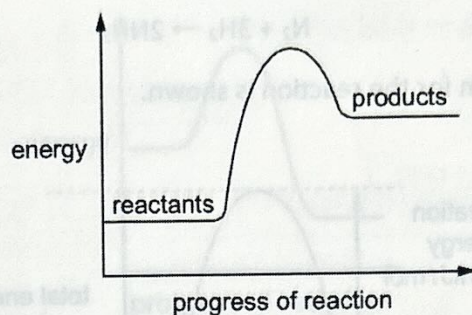
	energy level diagram	energy transfer
A		energy is transferred from the surroundings to the reaction
B		energy is transferred from the surroundings to the reaction ✓
C		energy is transferred from the reaction to the surroundings
D		energy is transferred from the reaction to the surroundings ✓

CORRECTION

CORRECTION



13. An energy level diagram for a reaction is shown.



Which statement about the reaction is correct?

- A. Heat is released.
- B. It is a combustion reaction.
- C. It is an endothermic reaction.
- D. The temperature increases.

14. Which row describes the energy level diagram and energy change in an exothermic reaction?

	energy level diagram	energy is
<b>A</b>	reactants higher than products	absorbed
<input checked="" type="radio"/> <b>B</b>	reactants higher than products	released ✓
<b>C</b>	reactants lower than products	absorbed
<b>D</b>	reactants lower than products	released ✓

A. 1 and 3 only

B. 1 and 4 only

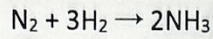
C. 2 and 3 only

D. 2 and 4 only

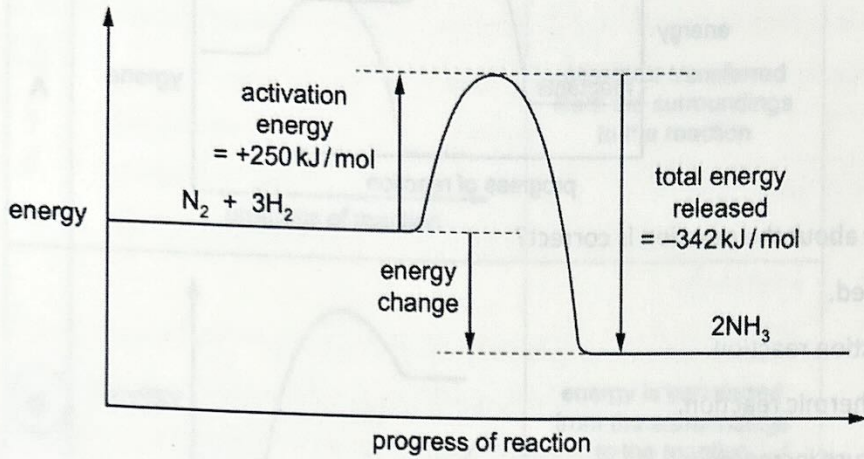
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15. The equation for the formation of ammonia is shown.



The energy level diagram for the reaction is shown.



What is the energy change for the reaction?

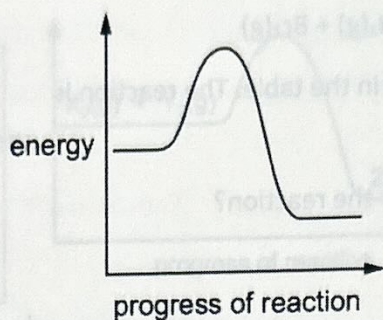
- A.  $-592 \text{ kJ/mol}$   
 B.  $-92 \text{ kJ/mol}$   
 C.  $+92 \text{ kJ/mol}$   
 D.  $+592 \text{ kJ/mol}$

CORRECTION

CORRECTION



16. An energy level diagram for a reaction is shown.



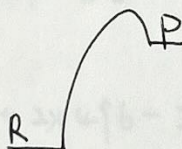
Which statement and explanation about this reaction are correct?

	statement	explanation
<b>A</b>	the reaction is endothermic	the products have more energy than the reactants
<b>B</b>	the reaction is endothermic	the products have less energy than the reactants
<b>C</b>	the reaction is exothermic ✓	the products have more energy than the reactants
<b>D</b>	the reaction is exothermic ✓	the products have less energy than the reactants ✓

17. Which statements about endothermic reactions are correct?

- 1 The energy of the products is greater than the energy of the reactants. ✓
- 2 The energy of the reactants is greater than the energy of the products. ✗
- 3 The temperature of the surroundings increases during the reaction. ✗
- 4 The temperature of the surroundings decreases during the reaction. ✓

- A. 1 and 3 only  
**B.** 1 and 4 only  
 C. 2 and 3 only  
 D. 2 and 4 only

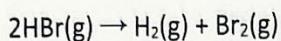


CORRECTION

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18. Hydrogen bromide decomposes to form hydrogen and bromine. The equation is shown.



The bond energies are shown in the table. The reaction is endothermic.

bond	bond energy in kJ/mol
Br-Br	+193
H-Br	+366
H-H	+436

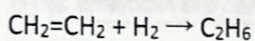
What is the energy change for the reaction?

- A. +263 kJ/mol  
 B. +103 kJ/mol  
 C. -103 kJ/mol  
 D. -263 kJ/mol

$$2 \times 366 - 436 - 193 = +103$$

19. Ethene reacts with hydrogen.

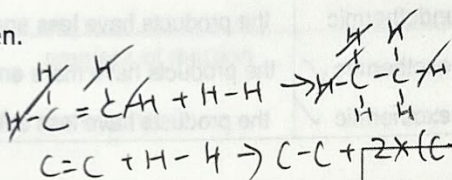
The equation is shown.



The bond energies are shown in the table. The reaction is exothermic.

What is the energy change for the reaction?

- A. A -560 kJ/mol  
 B. -124 kJ/mol  
 C. +486 kJ/mol  
 D. +5496 kJ/mol



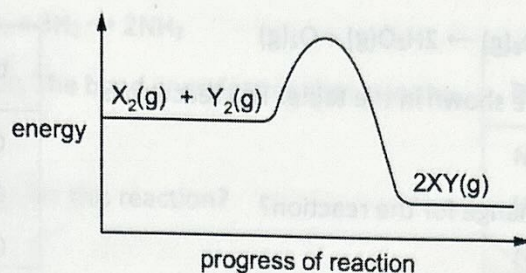
$$610 + 436 - \{50 + 4 \times 41\} = -124$$

bond	bond energy in kJ/mol
C-C	+350
C=C	+610
C-H	+410
H-H	+436

CORRECTION



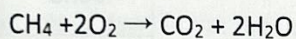
20. The energy level diagram for the reaction between  $X_2$  and  $Y_2$  to form  $XY$  gas is shown.



Which statement is correct?

- A. Energy is released when  $X_2$  and  $Y_2$  bonds are broken.   
 B. Energy is needed to form  $XY$  bonds.   
 C. The energy change,  $\Delta H$ , for the reaction is negative.   
 D. The reaction is endothermic.

21. Methane burns in oxygen to form carbon dioxide and water.

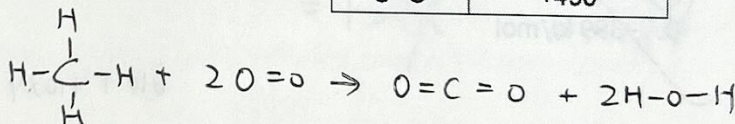


The bond energies are shown in the table.

What is the energy change for the reaction?

- A.  $-818$  kJ/mol   
 B.  $-323$  kJ/mol   
 C.  $+323$  kJ/mol   
 D.  $+818$  kJ/mol

bond	bond energy in kJ/mol
C-H	+410
C=O	+805
O-H	+460
O=O	+496

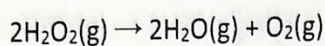


$$4 \times 410 + 2 \times 496 - 2 \times 805 - 4 \times 460 = 2632 - 3450 = -818$$

CORRECTION



22. Hydrogen peroxide, H-O-O-H, decomposes to form water and oxygen.



The bond energies are shown in the table. The reaction is exothermic.

bond	bond energy in kJ/mol
O-H	+460
O-O	+150
O=O	+496

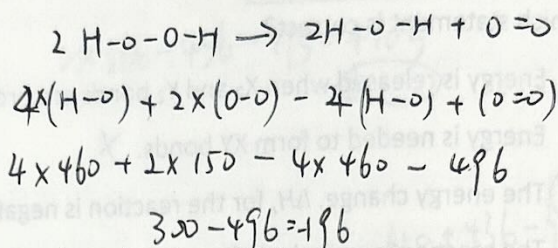
What is the energy change for the reaction?

A. -346 kJ/mol

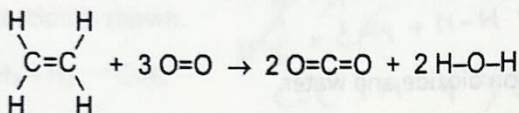
B. -196 kJ/mol

C. +196 kJ/mol

D. +346 kJ/mol



23. Ethene burns in oxygen to form carbon dioxide and water vapour.



The bond energies are shown in the table.

What is the energy change for the reaction?

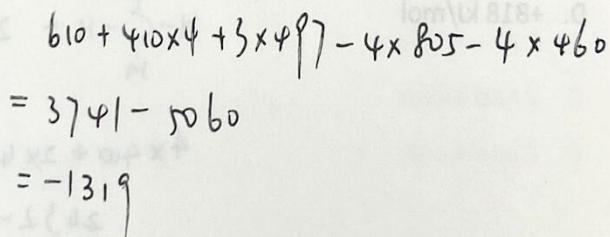
A. -2959 kJ/mol

B. -2313 kJ/mol

C. -1319 kJ/mol

D. -399 kJ/mol

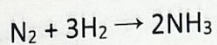
bond	bond energy in kJ/mol
C=C	+610
C-H	+410
O=O	+497
C=O	+805
O-H	+460



CORRECTION



24. Nitrogen reacts with hydrogen to produce ammonia.



The reaction is exothermic. The bond energies are shown in the table.

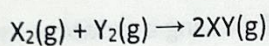
bond	bond energy in kJ/mol
$\text{N}\equiv\text{N}$	945
$\text{H}-\text{H}$	436
$\text{N}-\text{H}$	390

What is the energy change for this reaction?

- A. -1473 kJ/mol  
 B. -87 kJ/mol  
 C. 87 kJ/mol  
 D. 1473 kJ/mol

$$\begin{aligned} & 945 + 3 \times 436 - 6 \times 390 \\ & = 2253 - 2340 \\ & = -87 \end{aligned}$$

25. Two elements, X and Y, react together to form a covalent molecule as shown. The reaction is exothermic.



The bond energies are shown in the table.

What is the energy change for the reaction?

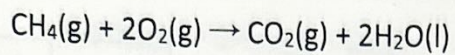
- A. +184 kJ/mol  
 B. -184 kJ/mol  
 C. +247 kJ/mol  
 D. -247 kJ/mol

bond	bond energy in kJ/mol
$\text{X}-\text{X}$	436
$\text{Y}-\text{Y}$	242
$\text{X}-\text{Y}$	431

$$\begin{aligned} & 436 + 242 - 431 \times 2 \\ & = +247 \\ & \quad \quad \quad = -184 \end{aligned}$$

CORRECTION





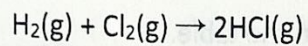
The bond energies are shown in the table.

bond	bond energy in kJ/mol
C-H	410
C-O	360
C=O	805
O-H	460
O-O	146
O=O	496

What is the energy change for this reaction?

- A. -818kJ/mol
- B. -102kJ/mol
- C. +102kJ/mol
- D. +818kJ/mol

27. Hydrogen reacts with chlorine according to the following equation.



The reaction is exothermic.

Which statement about this reaction is correct?

- A. Energy absorbed for bond breaking is greater than the energy released in bond making.
- B. Energy absorbed for bond breaking is less than the energy released in bond making.
- C. Energy released in bond breaking is greater than the energy absorbed in bond making.
- D. Energy released in bond breaking is less than the energy absorbed in bond making.

CORRECTION



28. A student investigated the temperature changes when two different solids, solid C and solid D, dissolved in water.

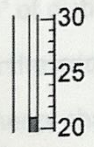
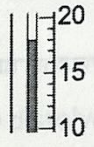
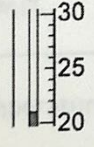
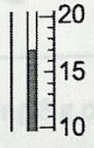
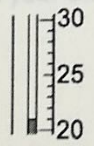
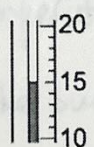
Two experiments were done.

Experiment 1

- Using a measuring cylinder, 40 cm<sup>3</sup> of distilled water was poured into a polystyrene cup. The initial temperature of the distilled water was measured.
- 3 g of solid C was added to the polystyrene cup and the mixture was stirred with a thermometer. The temperature of the solution was measured after 1 minute.
- The procedure was repeated using 4 g of solid C.
- The procedure was repeated using 6 g of solid C.

(a) Use the thermometer diagrams to record the results in the table.

Calculate and record the temperature change in each case, including whether the temperature increased (+) or decreased (-).

mass of solid C/g	thermometer diagram	initial temperature of the distilled water/°C	thermometer diagram	temperature of the solution after 1 min/°C	temperature change/°C
3		21		18	-3
4		21		17	-4
6		21		15	-6

CORRECTION

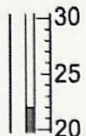
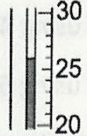
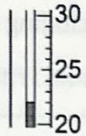
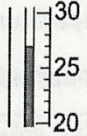
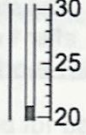
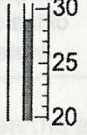
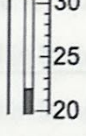
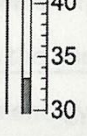


## Experiment 2

- Experiment 1 was repeated but using 3 g, 4 g, 6 g and 8 g of solid D.

(b) Use the thermometer diagrams to record the results in the table.

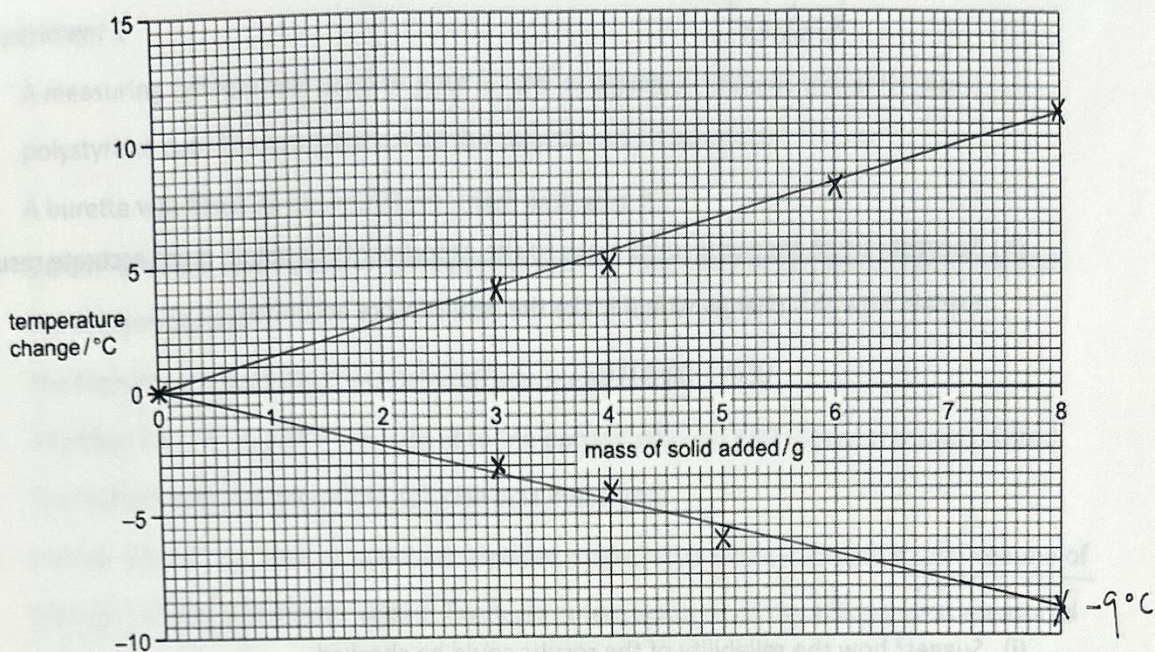
Calculate and record the temperature change in each case, including whether the temperature increased (+) or decreased (-).

mass of solid D/g	thermometer diagram	initial temperature of the distilled water/°C	thermometer diagram	temperature of the solution after 1 min/°C	temperature change/°C
3		22		26	+4
4		22		27	+5
6		21		29	+8
8		22		33	+11

CORRECTION



- (c) Plot the results for Experiments 1 and 2 on the grid. The (0,0) point has been plotted for you.  
 Draw two straight lines of best fit. 2  
 Clearly label your graphs.



- (d) Use your graph to estimate the temperature change after 1 minute if 8 g of solid C were added to 40 cm<sup>3</sup> of distilled water. 2  
 Show clearly on the grid how you worked out your answer.

- (e) What type of energy change occurs when solid D dissolves in water? 1

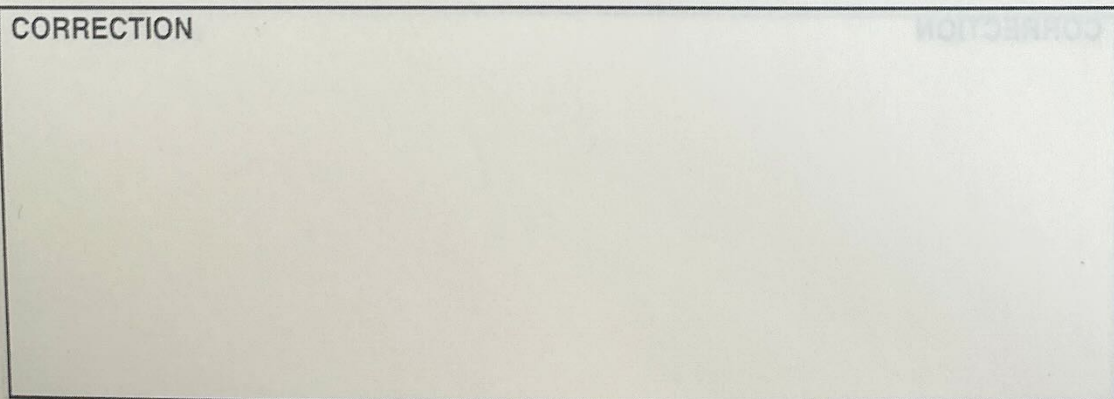
exothermic

- (f) Suggest the temperature of the solution containing 8 g of solid D if the solution were left for 2 hours. Explain your answer. 2

room temperature

heat to the surroundings

CORRECTION





(g) How would the temperature changes measured after 1 minute differ if the experiments were repeated using 80 cm<sup>3</sup> instead of 40 cm<sup>3</sup> of distilled water in each case?

halved

(h) Suggest one change you could make to the experiments to obtain more accurate results. Explain how this change would make the results more accurate.

use pipette

(i) Suggest how the reliability of the results could be checked.

repeat experiment

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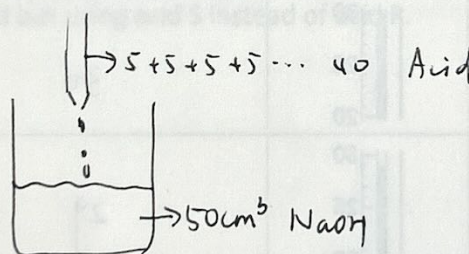
29. A student investigated how the temperature changed when aqueous sodium hydroxide reacted with solutions of two different acids, acid R and acid S.

Two experiments were done.

*Experiment 1*

- A measuring cylinder was used to pour  $50\text{ cm}^3$  of aqueous sodium hydroxide into a polystyrene cup. The temperature of the solution was measured.
- A burette was filled up to the  $0.0\text{ cm}^3$  mark with acid R.
- $5.0\text{ cm}^3$  of acid R was added to the aqueous sodium hydroxide in the polystyrene cup and the solution stirred.
- The highest temperature of the solution was measured.
- A further  $5.0\text{ cm}^3$  of acid R was added to the polystyrene cup and the solution was stirred.
- The highest temperature of the solution was measured.
- Further  $5.0\text{ cm}^3$  portions of acid R were added to the polystyrene cup until a total volume of  $40.0\text{ cm}^3$  of acid R had been added. The highest temperature of the solution was measured after each addition.

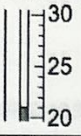
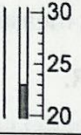
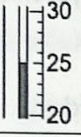
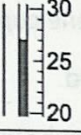
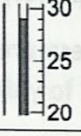
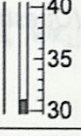
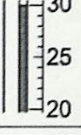
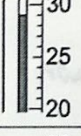
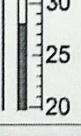
(Questions are on the following pages)



CORRECTION



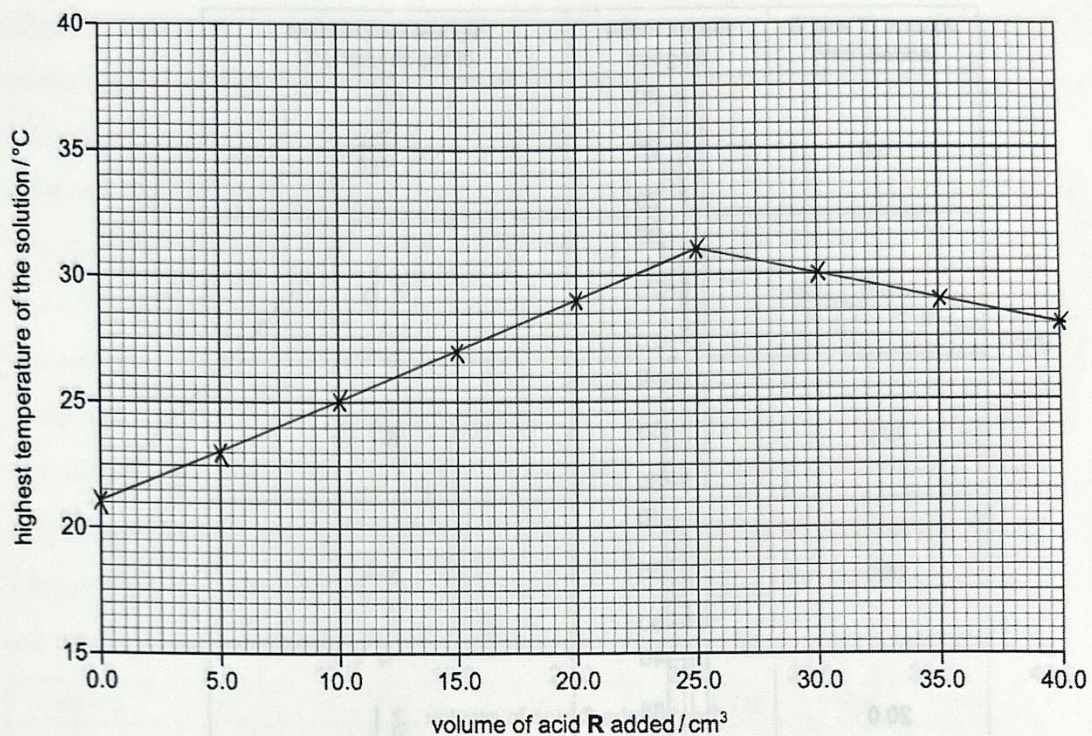
(a) Use the thermometer diagrams to record the results in the table.

volume of acid R added / cm <sup>3</sup>	thermometer diagram	highest temperature of the solution / °C
0.0		21
5.0		23
10.0		25
15.0		27
20.0		29
25.0		31
30.0		30
35.0		29
40.0		28

CORRECTION



(b) Plot the results for Experiment 1 on the grid and draw two intersecting straight line graphs.



(c) Use your graph to estimate the volume of acid S which must be added to neutralise 50 cm<sup>3</sup>

#### Experiment 2

- The burette was rinsed with distilled water and then with acid S.
- Experiment 1 was repeated but using acid S instead of acid R.

CORRECTION

CORRECTION



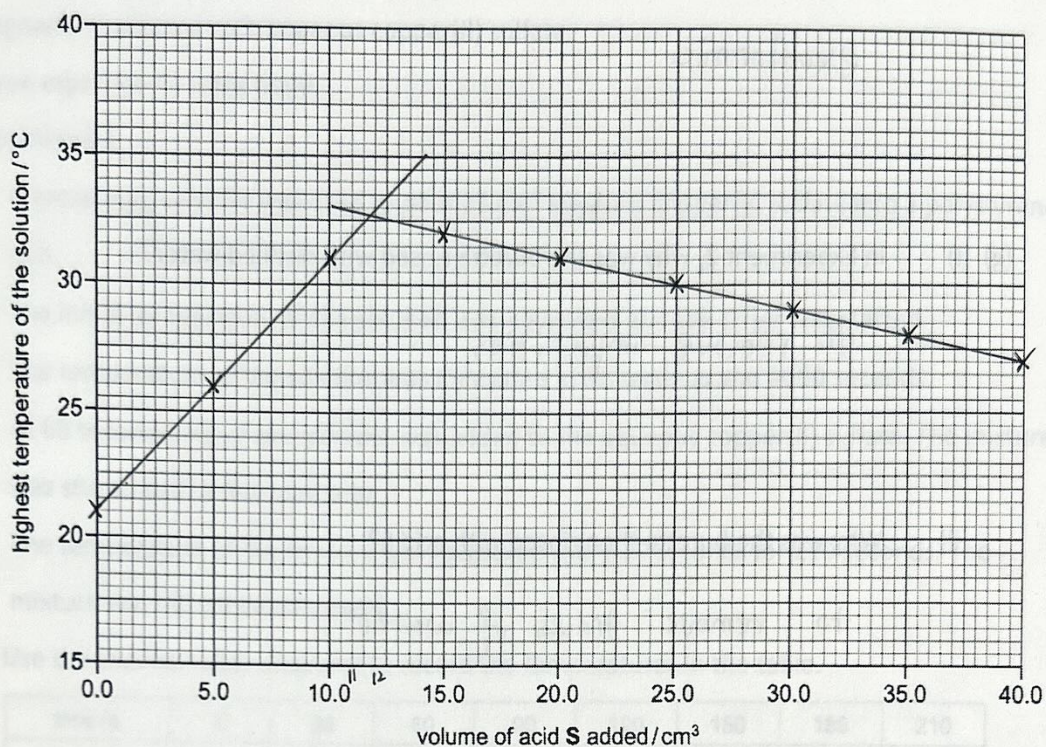
(c) Use the thermometer diagrams to record the results in the table.

volume of acid S added/cm <sup>3</sup>	thermometer diagram	highest temperature of the solution/°C
0.0		21
5.0		26
10.0		31
15.0		32
20.0		31
25.0		30
30.0		29
35.0		28
40.0		27

CORRECTION



(d) Plot the results for Experiment 2 on the grid and draw two intersecting straight line graphs.



(e) Use your graph to estimate the volume of acid S which must be added to neutralise 50 cm<sup>3</sup> of aqueous sodium hydroxide.

(i) Show clearly on the grid how you worked out your answer. 11.8 cm<sup>3</sup>

(ii) Suggest how the volume in (e)(i) would differ if the experiment were repeated using 25 cm<sup>3</sup> instead of 50 cm<sup>3</sup> of aqueous sodium hydroxide.

Explain your answer.

half volume of acid

the amount of NaOH is halved

CORRECTION



(f) What type of energy change occurs when acid S reacts with aqueous sodium hydroxide?

exothermic

(g) (i) In Experiment 2, why was the burette rinsed with distilled water?

to remove impurities

(ii) Why was the burette then rinsed with acid S?

to remove traces of water

(h) Describe one source of error in Experiment 2. Suggest an improvement to reduce this source of error.

Heat loss

use insulated cup with lid

CORRECTION

CORRECTION



30. A student investigated the temperature changes when two different metals, zinc and magnesium, reacted with aqueous copper(II) sulfate.

Three experiments were done.

*Experiment 1*

- A measuring cylinder was used to pour 25 cm<sup>3</sup> aqueous copper(II) sulfate into a polystyrene cup.
- The initial temperature of the solution was measured and the timer was started.
- The temperature of the solution was measured at 30 seconds and at 60 seconds.
- At 60 seconds, 5 g of zinc powder was added to the aqueous copper(II) sulfate. The mixture was stirred with a thermometer.
- The temperature of the mixture was measured every 30 seconds for 210 seconds. The mixture was stirred continuously.

(a) Use the thermometer diagrams to record the temperatures in the table.

time/s	0	30	60	90	120	150	180	210
thermometer diagram								
temperature of mixture/°C	25	25	25	41	46	46	45	44

*Experiment 2*

- Experiment 1 was repeated using 5 g of magnesium powder instead of zinc powder.

(b) Use the thermometer diagrams to record the temperatures in the table.

time/s	0	30	60	90	120	150	180	210
thermometer diagram								
temperature of mixture/°C	27	27	27	57	79	79	77	75

CORRECTION



Experiment 3

- Experiment 1 was repeated using 5 g of zinc granules instead of zinc powder.

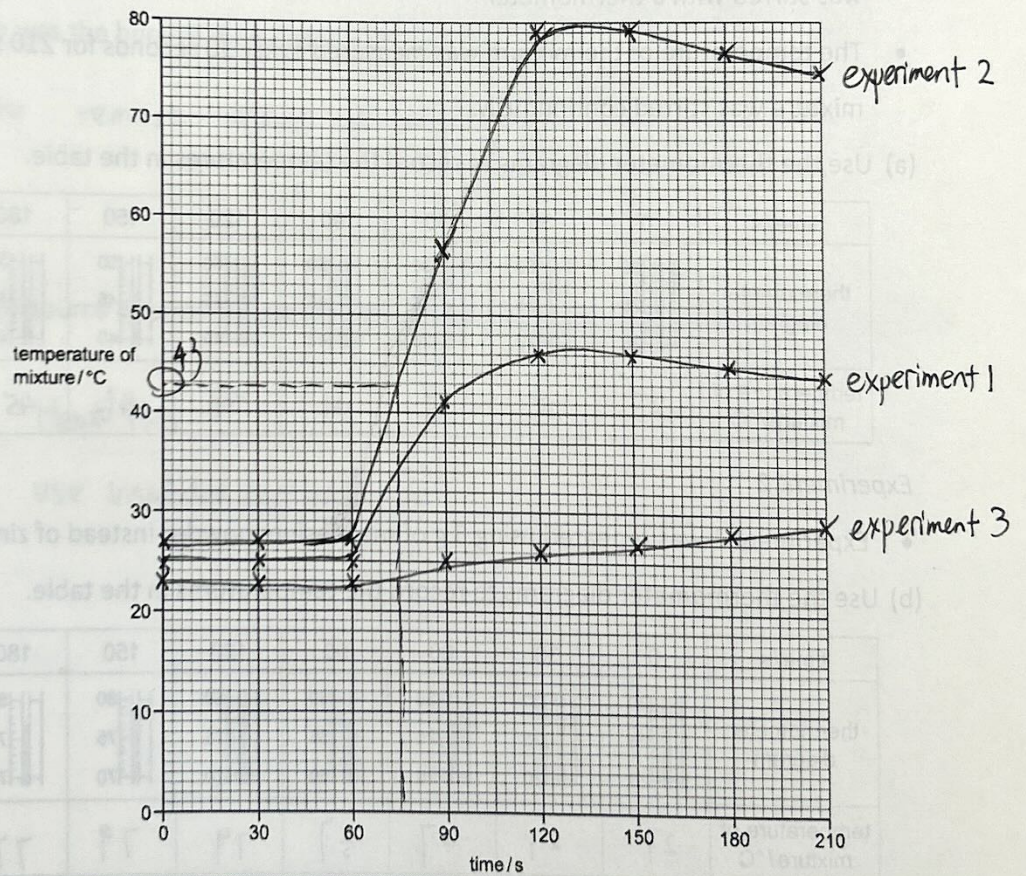
(c) Use the thermometer diagrams to record the temperatures in the table.

time/s	0	30	60	90	120	150	180	210
thermometer diagram								
temperature of mixture/°C	23	23	23	25	26	27	28	29

(d) Plot the results for Experiments 1–3 on the grid and draw three smooth line graphs.

Clearly label your lines.

2



CORRECTION



- (e) From your graph, deduce the temperature of the mixture in Experiment 2 after 75 seconds. Show clearly on the grid how you worked out your answer. 2

43°C

- (f) From the results, which Experiment was the most exothermic? Explain your answer. 2

experiment 2  
the highest temperature increase

- (g) Predict the temperature of the mixture in Experiment 2 after 2 hours. Explain your answer 2

room temperature

- (h) When doing the experiments, what would be the advantage of taking the temperature readings every 15 seconds? 2

more reading  
a smoother graph

- (i) Explain why a copper can should not be used in place of the polystyrene cup in these experiments. 1

copper is a good thermal conductor.

CORRECTION



31. A student investigated the temperature changes when two different solids, N and O, dissolve in water.

Two experiments were done.

*Experiment 1*

- Using a measuring cylinder, 30 cm<sup>3</sup> of distilled water was poured into a polystyrene cup.
- The initial temperature of the distilled water was measured.
- Solid N was added to the distilled water, a timer started and the mixture was stirred with a stirring thermometer.
- The temperature of the mixture was measured every 30 seconds for three minutes (180 seconds).

(a) Use the thermometer diagrams to record the temperatures in the table.

time/s	0	30	60	90	120	150	180
thermometer diagram							
temperature of mixture / °C	22	24	25	26	27	27	26

*Experiment 2*

Experiment 1 was repeated using a new polystyrene cup and solid O instead of solid N.

(b) Use the thermometer diagrams to record the temperatures in the table.

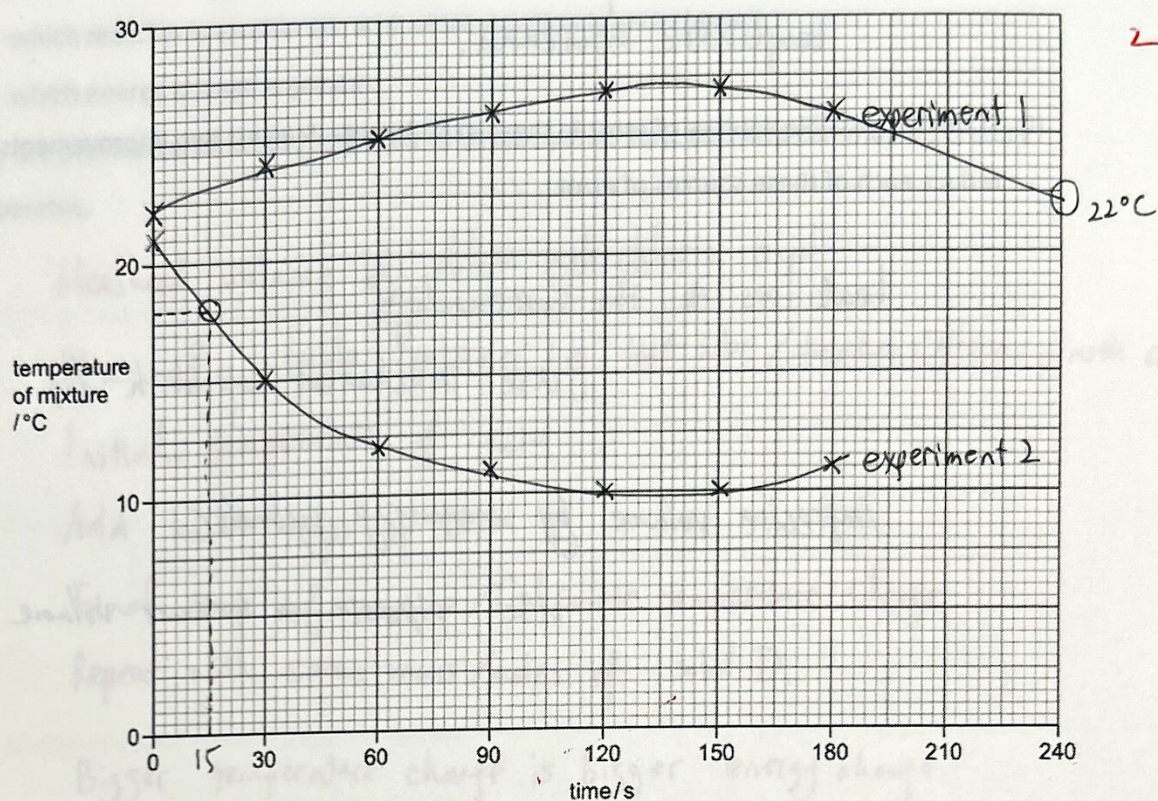
time/s	0	30	60	90	120	150	180
thermometer diagram							
temperature of mixture / °C	21	15	12	11	10	10	11

CORRECTION



(c) Plot the results for Experiments 1 and 2 on the grid. Draw two smooth line graphs.

Clearly label your graphs.



(d) (i) From your graph, deduce the time taken for the initial temperature of the solution in Experiment 2 to change by  $3^{\circ}\text{C}$ .

Show clearly on the grid how you worked out your answer.

15 s

(ii) Extend your graph for Experiment 1 to give the expected temperature of the mixture after 240 seconds.

22°C

CORRECTION



(e) Is the energy change in Experiment 2 exothermic or endothermic? Explain your answer.

endothermic  
temperature decreases.

2

(f) State two possible sources of error in these experiments. Suggest two improvements to reduce each of these sources of error.

4

heat loss to the surroundings  
use insulated cup with lid

imprecise volume by measuring cylinder  
use pipette to measure volume

CORRECTION

CORRECTION



32. When solid C and solid D separately react with dilute hydrochloric acid, one reaction is exothermic and one reaction is endothermic. Plan an investigation to determine:

- which reaction is exothermic and which reaction is endothermic
- which energy change is greater.

You are provided with solid C and solid D, dilute hydrochloric acid and common laboratory apparatus.

Measured volume of dilute hydrochloric acid

Use of suitable container (eg test tube / beaker / flask / plastic cup)

Initial temperature of acid

Add known mass of solid C

Final temp of mixture / Calculate temperature change

Repeat with same mass / moles of solid D.

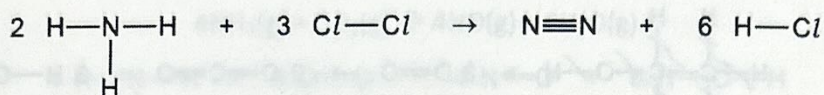
Bigger temperature change is bigger energy change.

temperature increase is exothermic / temp decrease is endothermic process.

CORRECTION



34. The chemical equation can be represented as shown.



Use the bond energies in the table to determine the energy change,  $\Delta H$ , for the reaction between ammonia and chlorine.

bond	bond energy in kJ/mol
N-H	390
Cl-Cl	240
N≡N	945
H-Cl	430

(a) energy needed to break bonds

$$6 \times 390 + 3 \times 240 = 3060$$

(b) energy released when bonds are formed

$$945 + 6 \times 430 = 3525$$

(c) energy change,  $\Delta H$ , for the reaction between ammonia and chlorine

$$\Delta H = 3060 - 3525 = -465 \text{ kJ/mol}$$

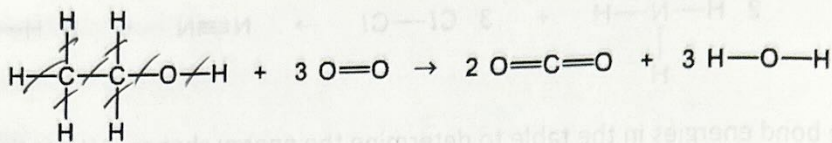
(d) Is the reaction endothermic or exothermic? Explain your answer.

exothermic negative value of  $\Delta H$ .

CORRECTION



35. The equation for the complete combustion of ethanol is shown.



Use the bond energies in the table to calculate the energy change, in kJ/mol, for the complete combustion of ethanol.

bond	bond energy in kJ/mol
C-C	347
C-H	413
C-O	358
C=O	805
O-H	464
O=O	498

$$\begin{aligned}
 \Sigma \text{BE}(\text{Reactants}) &= 5 \times (\text{C-H}) + (\text{C-C}) + (\text{C-O}) + (\text{O-H}) + 3 \times (\text{O=O}) \\
 &= 5 \times 413 + 347 + 358 + 464 + 3 \times 498 \\
 &= 4728
 \end{aligned}$$

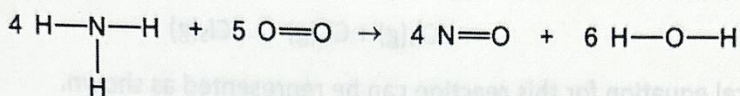
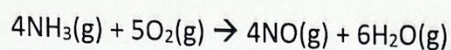
$$\begin{aligned}
 \Sigma \text{BE}(\text{Products}) &= 2 \times 2 \times (\text{C=O}) + 3 \times 2 \times (\text{H-O}) \\
 &= 4 \times 805 + 6 \times 464 \\
 &= 6004
 \end{aligned}$$

$$\Delta H = 4728 - 6004 = -1276 \text{ kJ/mol}$$

CORRECTION



36. Ammonia reacts with oxygen as shown.



Use the bond energies in the table to calculate the energy change, in kJ/mol, which occurs when one mole of  $\text{NH}_3$  reacts.

bond	N-H	O=O	N=O	O-H
bond energy in kJ/mol	391	498	587	464

$$4 \times 3 \times 391 + 5 \times 498 - 4 \times 587 - 6 \times 2 \times 464$$

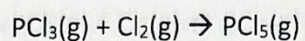
$$= 7182 - 7916 = -734 \text{ kJ/mol}$$

CORRECTION

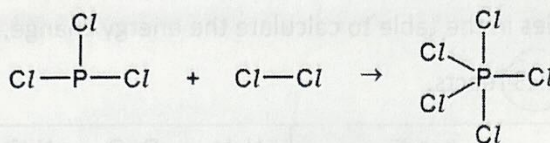
CORRECTION



37. Gaseous phosphorus(III) chloride,  $\text{PCl}_3$ , reacts with gaseous chlorine to form gaseous phosphorus(V) chloride,  $\text{PCl}_5$ .



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



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

bond	bond energy in kJ/mol
P-Cl	326
Cl-Cl	243

$$326 \times 3 + 243 - 326 \times 5 = -409$$

- (b) Deduce whether the energy change for this reaction is exothermic or endothermic. Explain your answer.

exo

negative value of  $\Delta H$

CORRECTION

CORRECTION