

Chemical energetics

30 questions: 15 multiple choice, 15 structured.

1 Core Exothermic and endothermic reactions [1]

A student burns a small piece of magnesium ribbon in a Bunsen flame. The magnesium burns brightly and the surrounding air becomes noticeably warmer. What type of reaction is this?

- A Exothermic, because thermal energy is transferred to the surroundings
- B Endothermic, because thermal energy is transferred to the surroundings
- C Exothermic, because thermal energy is taken in from the surroundings
- D Endothermic, because thermal energy is taken in from the surroundings

2 Core Exothermic and endothermic reactions [1]

A student dissolves solid potassium nitrate in water in a test tube. The temperature of the solution falls from 20°C to 12°C. What type of process is this?

- A Exothermic, because thermal energy is taken in from the surroundings
- B Endothermic, because thermal energy is taken in from the surroundings
- C Exothermic, because thermal energy is released to the surroundings
- D Endothermic, because thermal energy is released to the surroundings

3 Core Exothermic and endothermic reactions [1]

When the two components of an epoxy adhesive are mixed, they react together and the mixture becomes noticeably warm as it hardens. What type of reaction is taking place?

- A Exothermic, because thermal energy is transferred to the surroundings
- B Endothermic, because thermal energy is transferred to the surroundings
- C Exothermic, because thermal energy is taken in from the surroundings
- D Endothermic, because thermal energy is taken in from the surroundings

4**Core**

Exothermic and endothermic reactions

[1]

The reaction pathway for the complete combustion of carbon can be described using two energy values, on the same relative energy scale: the reactants (carbon and oxygen) have an energy of 0 kJ/mol, and the products (carbon dioxide) have an energy of -394 kJ/mol. What is the value of ΔH for this reaction?

- A +394 kJ/mol
 - B -197 kJ/mol
 - C -394 kJ/mol
 - D +788 kJ/mol
-

5**Supplement**

Exothermic and endothermic reactions

[1]

Petrol (mainly octane) burns inside a car engine. What is the sign of ΔH for this combustion reaction?

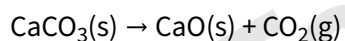
- A Positive, because the reaction is exothermic
 - B Positive, because the reaction is endothermic
 - C Negative, because the reaction is endothermic
 - D Negative, because the reaction is exothermic
-

6**Supplement**

Exothermic and endothermic reactions

[1]

Limestone (calcium carbonate) is heated strongly in an industrial lime kiln:



The reaction only continues while the limestone is heated. What is the sign of ΔH for this reaction?

- A Positive, because the reaction is exothermic
- B Positive, because the reaction is endothermic
- C Negative, because the reaction is exothermic
- D Negative, because the reaction is endothermic

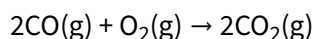
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Supplement

Exothermic and endothermic reactions

[1]

A catalytic converter contains platinum and rhodium, which speed up the conversion of carbon monoxide to carbon dioxide in a car's exhaust:



Which statement correctly defines the activation energy of this reaction?

- A The total energy released when the reaction takes place
- B The minimum energy that colliding particles must have in order to react
- C The energy needed to break all the bonds in the reactants
- D The difference in energy between the reactants and the products

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Supplement

Exothermic and endothermic reactions

[1]

Hydrogen gas reacts with iodine vapour: $\text{H}_2\text{(g)} + \text{I}_2\text{(g)} \rightleftharpoons 2\text{HI(g)}$. Without a catalyst, the reaction has an activation energy of 165 kJ/mol. In the presence of a platinum catalyst, the reaction follows an alternative pathway with an activation energy of 55 kJ/mol. What effect does the platinum catalyst have on the enthalpy change, ΔH , of the reaction?

- A ΔH is unchanged
- B ΔH decreases by 110 kJ/mol
- C ΔH increases by 110 kJ/mol
- D ΔH becomes zero

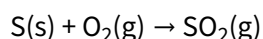
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Supplement

Exothermic and endothermic reactions

[1]

Sulfur burns in oxygen to form sulfur dioxide:



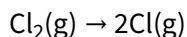
Which statement correctly describes the energy changes during this reaction?

- A Breaking the O=O bond releases energy, and forming the S=O bonds also releases energy
- B Breaking the O=O bond absorbs energy, and forming the S=O bonds also absorbs energy
- C Breaking the O=O bond absorbs energy, and forming the S=O bonds releases energy
- D Breaking the O=O bond releases energy, and forming the S=O bonds absorbs energy

10 **Supplement** Exothermic and endothermic reactions

[1]

Chlorine gas in the upper atmosphere can be broken apart by ultraviolet light:



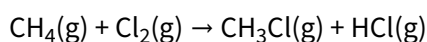
What type of process is this, and why?

- A Endothermic, because energy is absorbed as the Cl–Cl bond breaks
 - B Exothermic, because energy is released as the Cl–Cl bond breaks
 - C Exothermic, because energy is absorbed as the Cl–Cl bond breaks
 - D Endothermic, because energy is released as the Cl–Cl bond breaks
-

11 **Supplement** Exothermic and endothermic reactions

[1]

Methane reacts with chlorine in a free-radical substitution reaction:



This reaction is exothermic overall. What does this tell you about the bonds broken and the bonds formed?

- A The energy needed to break the bonds in the reactants is greater than the energy released forming the bonds in the products
 - B The energy needed to break the bonds in the reactants is exactly equal to the energy released forming the bonds in the products
 - C The energy needed to break the bonds in the reactants is less than the energy released forming the bonds in the products
 - D No bonds are broken in an exothermic reaction
-

12 **Supplement** Exothermic and endothermic reactions

[1]

Hydrogen reacts with chlorine: $\text{H}_2(\text{g}) + \text{Cl}_2(\text{g}) \rightarrow 2\text{HCl}(\text{g})$

Bond energies: H–H = 436 kJ/mol, Cl–Cl = 242 kJ/mol, H–Cl = 431 kJ/mol.

What is the value of ΔH for this reaction?

- A +184 kJ/mol
- B –247 kJ/mol
- C –184 kJ/mol
- D –1540 kJ/mol

13**Supplement**

Exothermic and endothermic reactions

[1]

A student adds yeast, which contains enzymes, to a solution of hydrogen peroxide, increasing the rate of its decomposition. What effect does the yeast have on the activation energy and on the enthalpy change, ΔH , of the reaction?

- A Activation energy decreases, ΔH decreases
 - B Activation energy unchanged, ΔH decreases
 - C Activation energy increases, ΔH unchanged
 - D Activation energy decreases, ΔH unchanged
-

14**Core**

Exothermic and endothermic reactions

[1]

A student adds excess zinc powder to 50 cm³ of copper(II) sulfate solution in an insulated polystyrene cup and stirs. The temperature rises from 22°C to 34°C over two minutes. What does this show about the reaction between zinc and copper(II) sulfate solution?

- A It is endothermic, because thermal energy is released to the surroundings
 - B It is exothermic, because thermal energy is released to the surroundings
 - C It is exothermic, because thermal energy is absorbed from the surroundings
 - D It is endothermic, because thermal energy is absorbed from the surroundings
-

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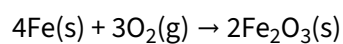
Exothermic and endothermic reactions

[1]

In the Haber process, the forward reaction $\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightarrow 2\text{NH}_3(\text{g})$ has $\Delta H = -92 \text{ kJ/mol}$. What is ΔH for the reverse reaction (the decomposition of ammonia into nitrogen and hydrogen)?

- A -92 kJ/mol
- B -46 kJ/mol
- C $+184 \text{ kJ/mol}$
- D $+92 \text{ kJ/mol}$

A simple hand warmer contains iron powder in a sealed sachet. When the sachet is opened, air enters and reacts slowly with the iron powder:



The temperature of the sachet rises noticeably and stays warm for several hours.

- (a) State what is meant by the term *exothermic reaction*. [2]

- (b) Using the hand warmer as an example, explain how you can tell that this reaction is exothermic. [2]

An instant cold pack works by dissolving solid ammonium nitrate in water. A student places 5 g of ammonium nitrate and 20 cm³ of water in an insulated cup and stirs. The temperature of the water falls from 21°C to 9°C over one minute.

- (a) State what is meant by the term *endothermic reaction*. [2]

- (b) State the sign of ΔH for the dissolving of ammonium nitrate in water, and explain your reasoning. [2]

- (c) On a reaction pathway diagram for this process, state whether the energy of the products (the dissolved ions in solution) would be drawn above or below the energy of the reactants (the solid ammonium nitrate and water), giving a reason for your answer. [2]

Propane burns completely in a camping stove. The reaction pathway for this combustion can be described using the following energy values, all on the same relative energy scale:

- energy of the reactants (propane + oxygen) = 100 kJ
- energy of the highest point on the pathway = 160 kJ
- energy of the products (carbon dioxide + water) = 20 kJ

(a) Calculate the activation energy, E_a , for the forward reaction. [1]

(b) Calculate the enthalpy change, ΔH , for the combustion of propane. [2]

(c) State whether the reaction is exothermic or endothermic, and explain how this can be seen from the position of the products relative to the reactants on the reaction pathway. [2]

(d) Calculate the activation energy for the reverse reaction (the decomposition of carbon dioxide and water back into propane and oxygen). [1]

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Exothermic and endothermic reactions

[5]

Living cells constantly carry out two important reactions:

- respiration: $\text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2 \rightarrow 6\text{CO}_2 + 6\text{H}_2\text{O}$, which releases energy for the cell to use
- photosynthesis: $6\text{CO}_2 + 6\text{H}_2\text{O} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2$, which requires energy absorbed from sunlight

(a) State, with a reason, whether respiration is exothermic or endothermic.

[2]

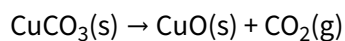
(b) State, with a reason, whether photosynthesis is exothermic or endothermic.

[2]

(c) State one way in which the two reactions above are related to each other.

[1]

When solid copper(II) carbonate is heated strongly in a test tube, it decomposes:



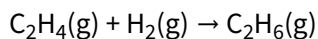
The green solid turns black, and heating must continue for the reaction to carry on.

- (a) State, with a reason, whether this reaction is exothermic or endothermic. [2]

- (b) Define the term *activation energy*. [2]

- (c) Suggest and explain the effect that adding a suitable catalyst would have on (i) the activation energy and (ii) the enthalpy change, ΔH , of this reaction. [2]

In margarine manufacture, hydrogen gas is added across the C=C double bond in ethene:



Use the bond energies in the table to answer the questions below.

Bond	Bond energy (kJ/mol)
C=C	612
C-C	347
C-H	413
H-H	436

- (a) State the bonds that are broken in this reaction, and calculate the total energy needed to break them.

[2]

- (b) State the bonds that are formed in this reaction, and calculate the total energy released when they form.

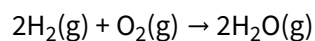
[2]

- (c) Use your answers to (a) and (b) to calculate ΔH for this reaction, and state whether it is exothermic or endothermic.

[3]

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A hydrogen fuel cell combines hydrogen and oxygen gas to produce water vapour:



Use the bond energies in the table to answer the questions below.

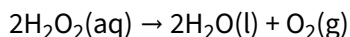
Bond	Bond energy (kJ/mol)
H-H	436
O=O	496
O-H	463

- (a) Calculate the total energy needed to break all the bonds in the reactants. [2]

- (b) Calculate the total energy released when all the bonds in the products form. [2]

- (c) Calculate ΔH for this reaction, and state whether it is exothermic or endothermic. [2]

Hydrogen peroxide decomposes slowly at room temperature:



Without a catalyst, this reaction has an activation energy of 75 kJ/mol. Adding manganese(IV) oxide as a catalyst provides an alternative pathway with an activation energy of 25 kJ/mol. In both cases, $\Delta H = -98$ kJ/mol.

- (a) Explain what the value 75 kJ/mol represents for this reaction. [2]

- (b) Explain, in terms of activation energy, why the manganese(IV) oxide catalyst increases the rate of decomposition. [2]

- (c) State the value of ΔH when the manganese(IV) oxide catalyst is used, and explain why it is not affected by the catalyst. [2]

A student adds 25 cm³ of dilute hydrochloric acid to 25 cm³ of dilute sodium hydroxide solution in an insulated cup, stirring and recording the temperature every 30 seconds.

Time (s)	0	30	60	90	120
Temperature (°C)	19.5	24.0	27.5	27.5	27.0

- (a) Calculate the increase in temperature between 0 s and its highest recorded value. [1]

- (b) State what is meant by the term *exothermic reaction*. [2]

- (c) Explain, using the data in the table, why the neutralisation reaction between hydrochloric acid and sodium hydroxide is described as exothermic. [3]

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Core

Exothermic and endothermic reactions

[5]

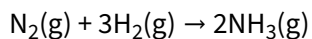
Two products sold for sports injuries work in opposite ways:

- a self-heating heat pack, which becomes warm when iron powder inside reacts with air
- an instant cold spray, which becomes cold when a chemical inside dissolves in water

(a) State which product contains a reaction that is exothermic, and explain your reasoning. [2]

(b) State which product contains a process that is endothermic, and explain your reasoning. [3]

In the Haber process, nitrogen and hydrogen react together:



Use the bond energies in the table to answer the questions below.

Bond	Bond energy (kJ/mol)
$\text{N}\equiv\text{N}$	944
$\text{H}-\text{H}$	436
$\text{N}-\text{H}$	391

- (a) Calculate the total energy needed to break all the bonds in the reactants. [2]

- (b) Calculate the total energy released when all the bonds in the products form. [2]

- (c) Calculate ΔH for this reaction, and state whether it is exothermic or endothermic. [2]

- (d) The reaction above is reversible. State whether the reverse reaction (the decomposition of ammonia into nitrogen and hydrogen) is exothermic or endothermic, and give the value of its enthalpy change. [1]

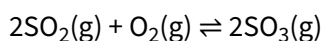
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Supplement

Exothermic and endothermic reactions

[6]

Sulfur dioxide reacts with oxygen in a reversible reaction:



For the forward reaction, $\Delta H = -196 \text{ kJ/mol}$ and the activation energy, E_a , is 250 kJ/mol .

- (a) State the value of ΔH for the reverse reaction (the decomposition of sulfur trioxide), giving a reason for your answer.

[2]

- (b) Calculate the activation energy for the reverse reaction.

[2]

- (c) State which direction of the reaction, forward or reverse, has the higher activation energy, and explain why, in terms of the energies of the reactants and products.

[2]

A student dissolves separate 5 g samples of two different solids in 20 cm³ of water each, in insulated cups, and records the temperature change.

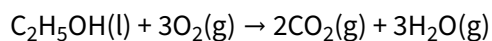
Solid	Starting temperature (°C)	Final temperature (°C)
Solid sodium hydroxide	20.0	32.5
Solid ammonium chloride	20.0	14.5

- (a) Calculate the temperature change for each solid. [2]

- (b) State, with a reason, whether dissolving sodium hydroxide is exothermic or endothermic. [2]

- (c) State, with a reason, whether dissolving ammonium chloride is exothermic or endothermic. [2]

Ethanol burns in a spirit burner:

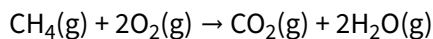


This reaction is exothermic overall, even though energy must first be put in to break the bonds in the reactants.

- (a) State whether breaking bonds is an exothermic or endothermic process, and whether making bonds is an exothermic or endothermic process. [2]

- (b) Explain, in terms of bond breaking and bond making, why the combustion of ethanol is exothermic overall even though bonds must first be broken. [3]

Methane burns completely in a plentiful supply of oxygen:



Use the bond energies in the table to answer the questions below.

Bond	Bond energy (kJ/mol)
C-H	413
O=O	496
C=O	805
O-H	463

- (a) Calculate the total energy needed to break all the bonds in the reactants.

[2]

- (b) Calculate the total energy released when all the bonds in the products form.

[2]

- (c) Calculate ΔH for the complete combustion of methane, showing your working, and state whether the reaction is exothermic or endothermic.

[3]

- (d) State whether the products would be drawn at a higher or lower energy level than the reactants on a reaction pathway diagram for this reaction, and explain your answer. [1]

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