Week 12

IGCSE Chemistry

Homework bundle for this week

本周作业合集

exercises.lol

Contents 目录

IGCSE Chemistry Name: ____________ Score: ______

1. A physical change:
   - ☐ makes no new substance and is usually reversible
   - ☐ always makes a new substance
   - ☐ cannot be reversed
   - ☐ always gives off a gas
2. For a reaction to happen, particles must:
   - ☐ collide with enough energy
   - ☐ be the same size
   - ☐ be at low temperature
   - ☐ be far apart
3. A catalyst speeds up a reaction by:
   - ☐ lowering the activation energy
   - ☐ raising the activation energy
   - ☐ being used up
   - ☐ cooling the reaction
4. A reversible reaction is shown by the symbol:
   - ☐ $\rightleftharpoons$
   - ☐ $\rightarrow$
   - ☐ $=$
   - ☐ $+$
5. The Haber process makes:
   - ☐ ammonia from nitrogen and hydrogen
   - ☐ sulfuric acid
   - ☐ oxygen
   - ☐ sodium chloride
6. Which increase the rate of reaction? (Select all that apply.)
   - ☐ higher temperature
   - ☐ higher concentration

- ☐ larger surface area (smaller pieces)
- ☐ lower temperature

Tick every correct option.

7. Which can be signs of a chemical change? (Select all that apply.)
   - ☐ a colour change
   - ☐ a gas given off
   - ☐ a precipitate forming
   - ☐ a change of shape only

   Tick every correct option.

8. Melting is a physical change because the substance stays the same.

   ☐ True ☐ False

9. On a graph of product against time, a steeper line means a faster reaction.

   ☐ True ☐ False

10. A steeper gradient on a rate graph means a faster reaction.

    ☐ True ☐ False

IGCSE Chemistry

1. **makes no new substance and is usually reversible**

   Physical changes keep the same substance.

2. **collide with enough energy**

   Collisions need at least the activation energy.

3. **lowering the activation energy**

   A lower Ea means more successful collisions.

4. $\rightleftharpoons$

   The $\rightleftharpoons$ sign shows a reversible reaction.

5. **ammonia from nitrogen and hydrogen**

   $N_2 + H_2 \rightleftharpoons NH_3$ in the Haber process.

6. **higher temperature; higher concentration; larger surface area (smaller pieces)**

   Lower temperature slows the rate.

7. **a colour change; a gas given off; a precipitate forming**

   A shape change alone is physical.

8. **True**

   Melted ice is still water — reversible.

9. **True**

   Steeper = more product per unit time = faster.

10. **True**

    Gradient measures rate.

6.1 Physical and chemical changes

Name: ____________ Class: ________ Date: __________ **Total: 8 marks**

KEY WORDS physical change 物理变化 • chemical change 化学变化 • precipitate 沉淀 • physical and chemical char
• iron 铁

Objective

Build the skills to answer exam questions on **physical and chemical changes 物理与化学变化** — telling them apart and recognising the signs of a chemical reaction.

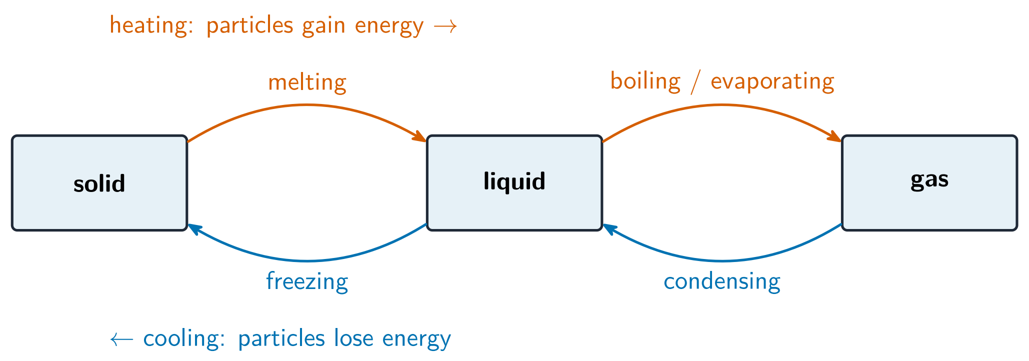
You must be able to:

- distinguish a physical change (no new substance) from a chemical change
- give the signs of a chemical reaction
- classify examples

1 Worked examples

■ Physical vs chemical

A chemical change makes a new substance (rust); a physical change does not



Melting and boiling are physical changes — no new substance

- **physical:** no new substance; easy to reverse (melting, dissolving).
- **chemical:** new substance(s); usually hard to reverse (burning, rusting).
- **signs of a reaction:** colour change, gas given off, energy change, precipitate forms.

2 Practice

2.1 State one difference between a physical and a chemical change. [1]

2.2 Give two signs that a chemical reaction has happened. [2]

3 Exam-style questions

3.1 Which is a physical change? [1]

- **A** burning magnesium
- **B** rusting iron
- **C** melting ice
- **D** neutralising an acid

3.2 Dissolving salt in water and burning a candle are both changes.

(a) State which is a physical change and which is a chemical change. [2]

(b) Explain your choice for the candle. [2]

Solutions

2.1 a chemical change makes a new substance; a physical change does not.

2.2 any two of: colour change; gas given off; energy/temperature change; a precipitate forms.

3.1 C. Melting ice makes no new substance — a physical change.

3.2 (a) dissolving salt = physical; burning a candle = chemical.
(b) burning makes new substances (e.g. carbon dioxide and water) and is hard to reverse.

16 Which statement about reactions is correct?

A A reaction that is vigorous at room temperature has a high activation energy.

B If ΔH for a reaction is positive, bond making in the formation of the products is endothermic.

C In an exothermic reaction, the energy required to break bonds is less than the energy released to make bonds.

D Reactions with a positive enthalpy change always transfer thermal energy to the surroundings.

IGCSE Chemistry: **s25 23**

27 A sample of calcium carbonate is heated strongly, and substances U and V are formed.

Substance U is a white solid. Substance V is a colourless gas.

What are substances U and V?

	U	V
A	calcium chloride	oxygen
B	calcium hydroxide	carbon dioxide
C	calcium oxide	carbon dioxide
D	calcium sulfate	oxygen

IGCSE Chemistry: **m25 22**

18 Which change is a physical change?

A cracking an alkane

B evaporating ethanol

C fermenting glucose

D neutralising an acid

IGCSE CHEMISTRY • EXERCISE SHEET

6.2 Rate of reaction

Name: ____________ Class: ________ Date: __________ **Total: 10 marks**

KEY WORDS concentration 浓度 • rate of reaction 反应速率 • particles 粒子 • catalyst 催化剂 • collision theory

Objective

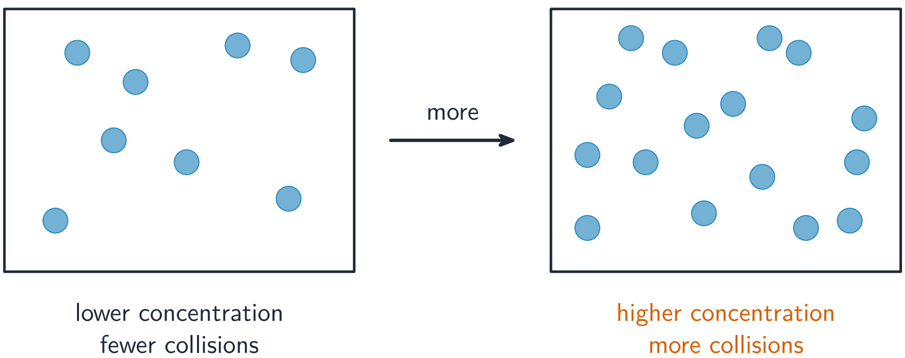
Build the skills to answer exam questions on the **rate of reaction 反应速率** — **collision theory 碰撞理论**, the factors that change the rate, **catalysts 催化剂**, and measuring rate.

You must be able to:

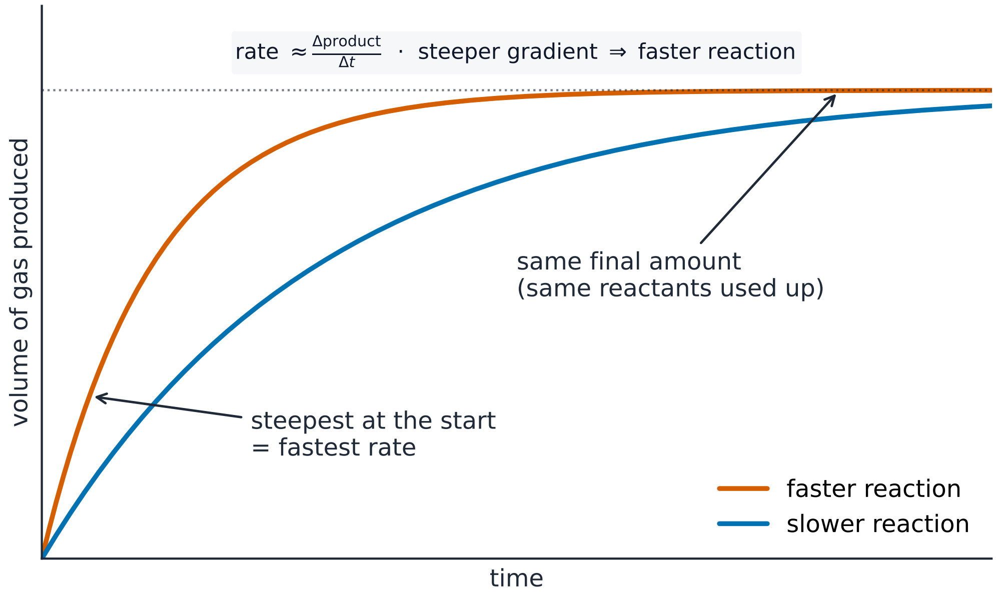
- use collision theory to explain the effect of concentration, surface area, temperature, pressure
- explain how a catalyst speeds up a reaction
- interpret a rate graph (steepest at the start, levels off)

1 Worked examples

Collision theory & rate graphs



More particles in the same volume collide more often → faster rate



Rate is fastest at the start (steepest), then levels off when the reaction finishes

- **catalyst:** lowers the activation energy → more successful collisions; not used up.

2 Practice

2.1 State two factors that increase the rate of a reaction. [2]

2.2 State how a catalyst speeds up a reaction. [1]

3 Exam-style questions

3.1 Increasing the temperature speeds up a reaction mainly because the particles: [1]

- **A** become larger
- **B** move faster and collide more often with enough energy
- **C** become catalysts
- **D** stop colliding

3.2 Marble chips react with hydrochloric acid, giving off carbon dioxide.

(a) Explain, using collision theory, why powdered marble reacts faster than large chips. [2]

(b) Describe one method to measure the rate of this reaction. [2]

3.3 On a graph of gas volume against time, explain why the line becomes less steep and then flat. [2]

Solutions

2.1 any two of: higher concentration; larger surface area; higher temperature; higher pressure (gases); a catalyst.

2.2 it lowers the activation energy, so more collisions are successful.

3.1 B. Hotter particles move faster, colliding more often and with more energy.

3.2 (a) a powder has a larger surface area; so there are more frequent collisions between acid particles and the marble, giving a faster rate.
(b) collect the gas in a gas syringe and record its volume at regular times; or stand the flask on a balance and record the falling mass.

3.3 as reactants are used up, there are fewer collisions per second, so the rate (steepness) decreases; when a reactant runs out the reaction stops, so the line is flat.

16 Hydrogen peroxide solution decomposes very slowly at room temperature to produce oxygen gas. This gas forms a rising foam when liquid detergent is added.

Five test-tubes are half-filled with hydrogen peroxide solution. A drop of liquid detergent is added to each one.

Different metal oxides are added to four of the test-tubes and the height of the foam formed after one minute is measured. The results are shown.

metal oxide	height of foam / cm
no metal oxide added	0.1
aluminium oxide	0.1
calcium oxide	0.2
copper(II) oxide	2.3
manganese(IV) oxide	5.4

Which conclusion can be drawn from these results?

A Metal oxides do **not** affect the rate of this reaction.

B All metal oxides increase the rate of this reaction and act as catalysts.

C Manganese(IV) oxide is the best catalyst of the four metal oxides tested.

D Only transition element oxides increase the rate of this reaction.

IGCSE Chemistry: **w25 22**

16 Aqueous sodium thiosulfate, $Na_2S_2O_3$, reacts with dilute hydrochloric acid to form a yellow precipitate of sulfur.

$$Na_2S_2O_3(aq) + 2HCl(aq) \rightarrow 2NaCl(aq) + H_2O(l) + S(s) + SO_2(g)$$

The precipitate forms more quickly when the reactants are heated.

Which statements explain this observation?

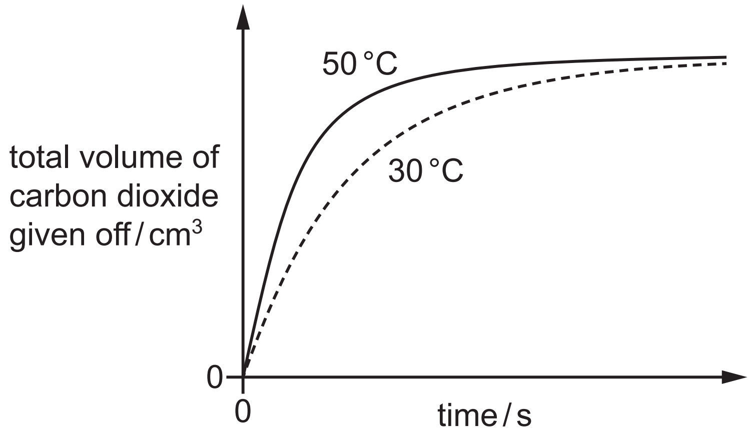
1 The reacting particles collide more frequently.

2 The collisions between reacting particles have more energy.

3 The activation energy of the reaction is lower.

A 1 and 2 **B** 1 and 3 **C** 1 only **D** 2 and 3

15 The graph shows the results of adding excess calcium carbonate to hydrochloric acid at 50 °C and at 30 °C. Only the temperature is changed.



Which row describes the reacting particles at 30 °C compared to those at 50 °C?

	frequency of collisions between particles	average kinetic energy of particles
A	higher	higher
B	higher	lower
C	lower	higher
D	lower	lower

15 Which statement describes the effect of adding a catalyst to a chemical reaction?

A The activation energy, E_a, of the reaction is increased.

B The enthalpy change, ΔH, of the reaction stays unchanged.

C The frequency of collisions between the particles is decreased.

D The kinetic energy of the particles is increased.

15 The rate of reaction between magnesium and dilute hydrochloric acid is increased by increasing the concentration of the acid.

How does this affect the reacting particles?

	collision rate of particles	proportion of particles with sufficient energy to react
A	increases	increases
B	increases	stays the same
C	stays the same	increases
D	stays the same	stays the same

2 A student investigates how the rate of reaction of magnesium ribbon with dilute acid changes as the concentration of the acid is changed. The student uses five solutions of the same acid, **A**, **B**, **C**, **D**, and **E**. Each solution has a different concentration. The acid is in excess in all experiments.

The student does five experiments.

Experiment 1

- Use a $50\,cm^3$ measuring cylinder to pour $30\,cm^3$ of acid **A** into a $100\,cm^3$ conical flask.
- Add a coil of magnesium ribbon to the acid in the conical flask and immediately start a stop-watch.
- Continually swirl the mixture in the conical flask until the magnesium ribbon disappears completely. Immediately stop the stop-watch and record the time in seconds to the nearest second.
- Empty and rinse the conical flask with distilled water.

Experiment 2

- Repeat Experiment 1 using $30\,cm^3$ of acid **B** instead of acid **A**.

Experiment 3

- Repeat Experiment 1 using $30\,cm^3$ of acid **C** instead of acid **A**.

Experiment 4

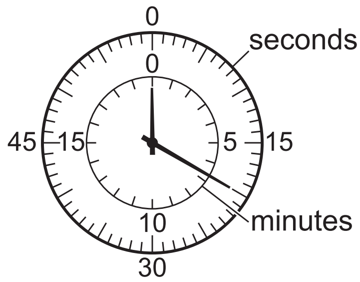
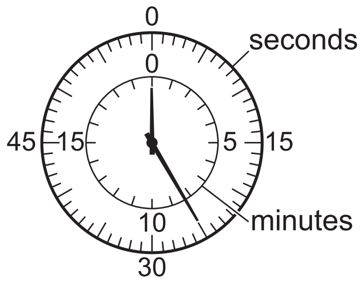
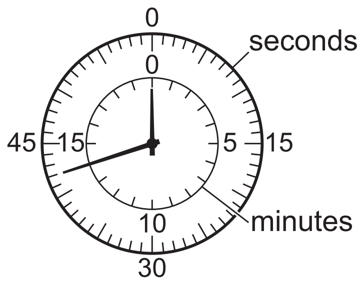
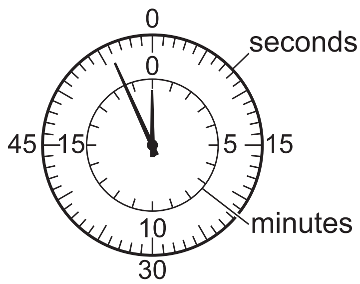
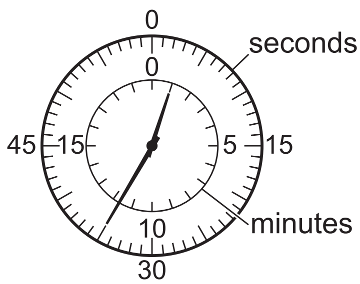
- Repeat Experiment 1 using $30\,cm^3$ of acid **D** instead of acid **A**.

Experiment 5

- Repeat Experiment 1 using $30\,cm^3$ of acid **E** instead of acid **A**.

(a) Use the stop-watch diagrams to complete Table 2.1

Table 2.1

experiment	acid	concentration of acid in mol/dm^3	stop-watch diagram	time for magnesium to disappear in s
1	**A**	2.0		
2	**B**	1.5		
3	**C**	1.0		
4	**D**	0.8		
5	**E**	0.5		

[2]

(b) Write a suitable scale on the *y*-axis and plot the results from Experiments 1 to 5 on Fig. 2.1.

Draw a line of best fit.

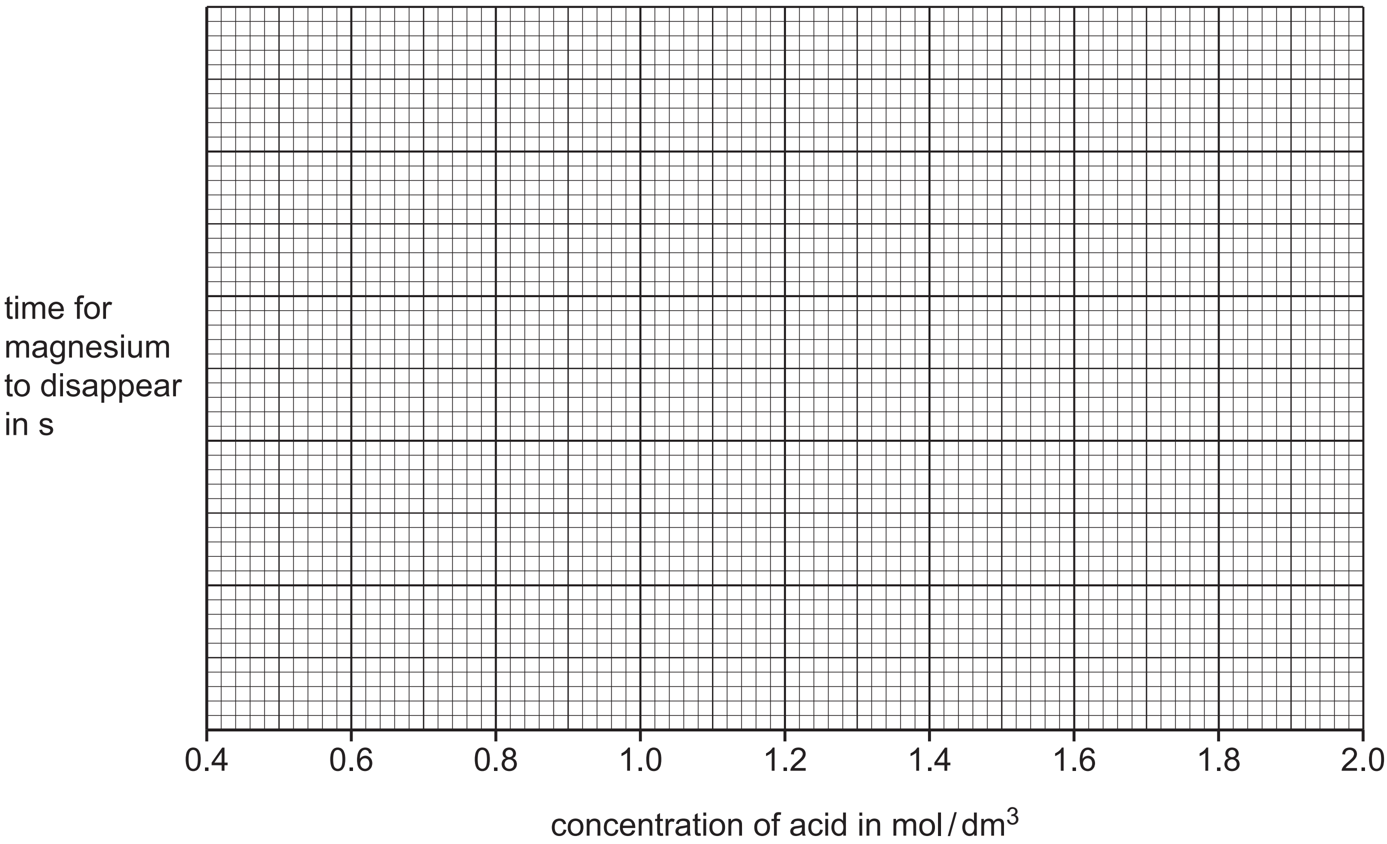


Fig. 2.1

[4]

(c) From your graph in Fig. 2.1, deduce the time for the magnesium to disappear when the concentration of the acid is 1.3 mol / dm^3.

Show clearly on Fig. 2.1 how you worked out your answer.

time for magnesium to disappear = ... s [2]

(d) The mean rate of reaction is calculated using the equation shown.

$$\text{mean rate of reaction} = \frac{\text{length of magnesium ribbon in cm}}{\text{time for magnesium to disappear in s}}$$

The length of each coil of magnesium ribbon used in all five experiments was 5 cm.

(i) Calculate the mean rate of reaction in Experiment 1. Give units for the rate you have calculated.

mean rate of reaction = ...

units ....

[2]

(ii) Deduce in which Experiment, 1, 2, 3, 4 or 5, the mean rate of reaction is the slowest.

[1]

(e) Explain why repeating each experiment is an improvement.

....

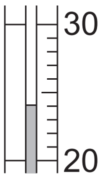
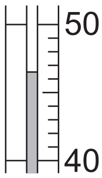
.... [1]

(f) The student does another experiment to find the temperature change when magnesium reacts with acid **A**.

- Use the measuring cylinder to pour 30 cm^3 of acid **A** into the 100 cm^3 conical flask.
- Measure the initial temperature of the acid in the conical flask.
- Add a coil of magnesium ribbon to the acid in the conical flask.
- Continually swirl the conical flask until the magnesium ribbon disappears completely.
- Measure the final temperature of the acid in the conical flask.

(i) Use the thermometer diagrams to complete Table 2.2.

Table 2.2

thermometer diagram for initial temperature	initial temperature / °C	thermometer diagram for final temperature	final temperature / °C	temperature change / °C
				

[2]

(ii) Explain why controlling the temperature of the acid so that it remains constant is an improvement.

....

.... [1]

(iii) Explain why using a polystyrene cup instead of the 100 cm^3 conical flask does **not** control the temperature of the acid.

....

.... [1]

(iv) Describe how the temperature of the acid can be controlled and kept constant.

....

.... [1]

[Total: 17]

2 A student investigates how the rate of reaction between dilute hydrochloric acid and aqueous sodium thiosulfate changes as the concentration of the aqueous sodium thiosulfate decreases. During the reaction, the solution slowly becomes cloudy. As the solution becomes cloudy, it becomes more difficult to see through the solution.

The student does five experiments.

Experiment 1

- Use a 50 cm^3 measuring cylinder to pour 50 cm^3 of aqueous sodium thiosulfate into a 100 cm^3 beaker.
- Use a 10 cm^3 measuring cylinder to pour 5 cm^3 of dilute hydrochloric acid into the beaker containing the aqueous sodium thiosulfate.
- Immediately start a stop-watch and stir the contents of the beaker.
- Stand the beaker on a printed sheet and look down from above the beaker as shown in Fig. 2.1.

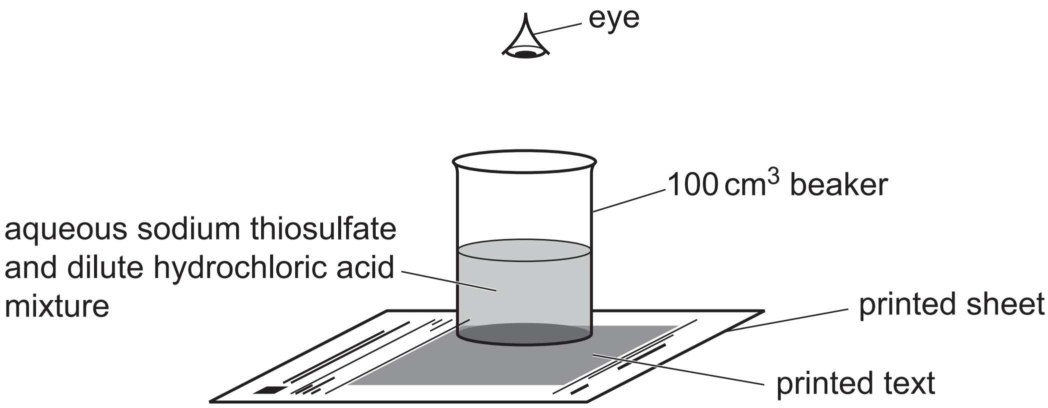


Fig. 2.1

- When the text on the printed sheet is **not** visible, stop the stop-watch and record the time to the nearest whole number of seconds.
- Empty the contents of the beaker and rinse the beaker with distilled water.

Experiment 2

- Repeat Experiment 1 using 40 cm^3 of aqueous sodium thiosulfate instead of 50 cm^3. Use the 50 cm^3 measuring cylinder to add 10 cm^3 of distilled water to the beaker **before** adding the dilute hydrochloric acid.

Experiment 3

- Repeat Experiment 2 using 30 cm^3 of aqueous sodium thiosulfate and 20 cm^3 of distilled water.

Experiment 4

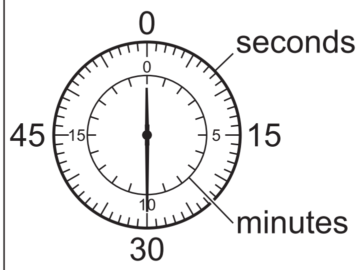
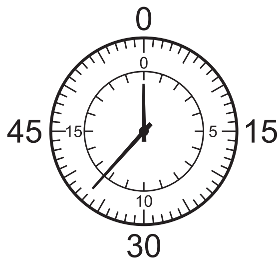
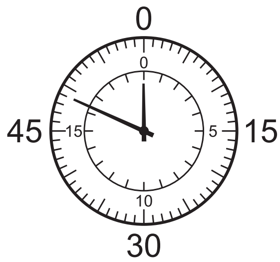
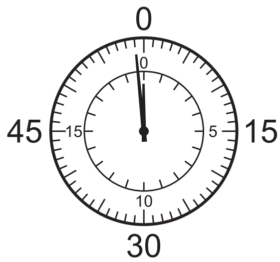
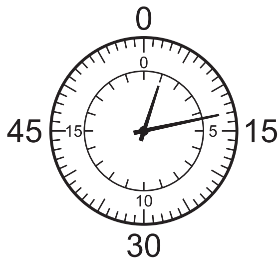
- Repeat Experiment 2 using 25 cm^3 of aqueous sodium thiosulfate and 25 cm^3 of distilled water.

Experiment 5

- Repeat Experiment 2 using 20 cm^3 of aqueous sodium thiosulfate and 30 cm^3 of distilled water.

(a) Use the information in the description of the experiments and the stop-watch diagrams to complete Table 2.1.

Table 2.1

experiment	volume of aqueous sodium thiosulfate / cm^3	volume of distilled water / cm^3	volume of dilute hydrochloric acid / cm^3	stop-watch diagram	time taken for text to **not** be visible / s
1	50	0	5		
2					
3					
4					
5					

[3]

(b) Write a suitable scale on the *y*-axis and plot the results from Experiments 1 to 5 on Fig. 2.2.

Draw a curve of best fit.

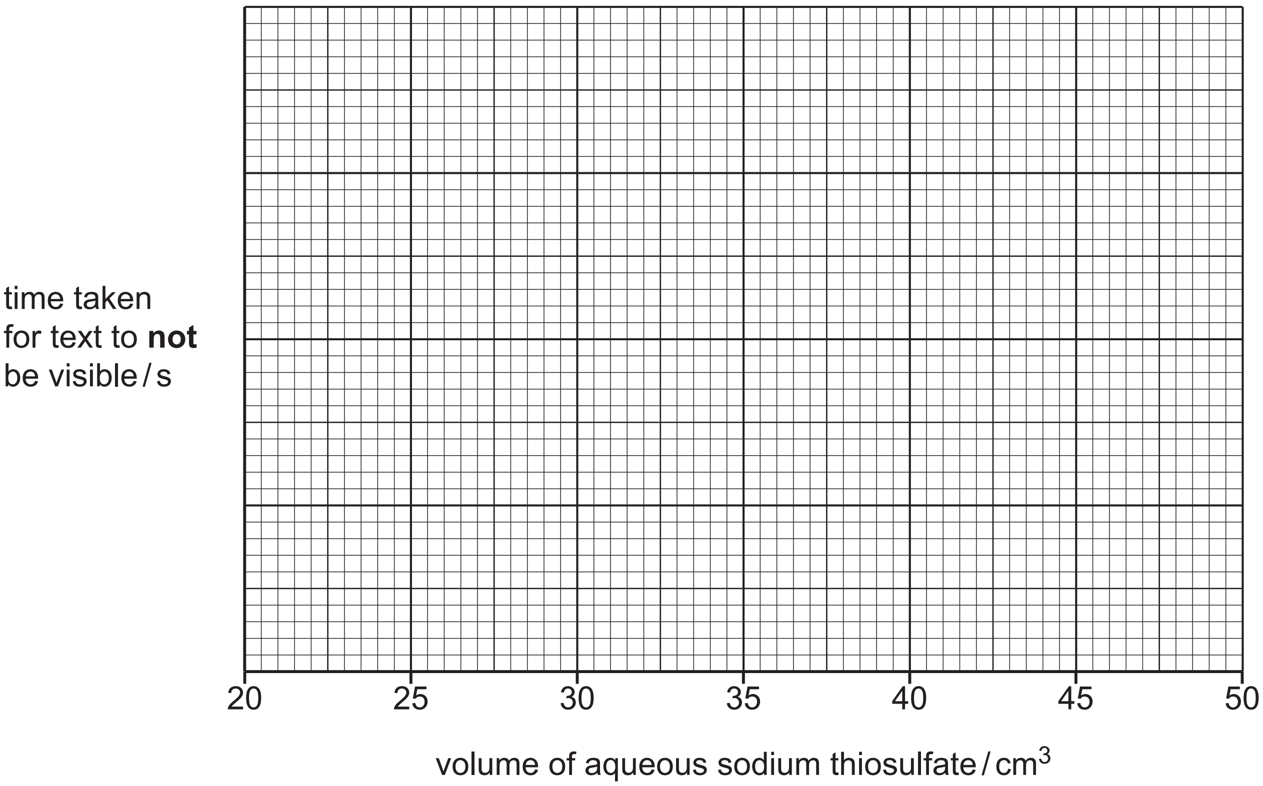


Fig. 2.2

[4]

(c) The relative rate of reaction in each experiment is calculated using the equation shown.

$$\text{relative rate of reaction} = \frac{1}{\text{time taken}}$$

(i) Calculate the relative rate of reaction in Experiment 1.
Do **not** give units for your answer.

relative rate of reaction = ... [1]

(ii) State in which Experiment, 1, 2, 3, 4 or 5, the relative rate of reaction was greatest.

.... [1]

(d) In each experiment the total volume of aqueous sodium thiosulfate and distilled water is constant.

(i) Calculate the volume of distilled water needed when the volume of aqueous sodium thiosulfate is 37 cm^3.

volume = ... [2]

(ii) From your graph in Fig. 2.2, deduce the time for the text to **not** be visible when the volume of aqueous sodium thiosulfate is 37 cm^3.

Show clearly on Fig. 2.2 how you worked out your answer.

time = ... s [2]

(iii) Explain why the total volume of aqueous sodium thiosulfate and distilled water is kept constant.

....

....

.... [1]

(e) **(i)** State why measuring the volume of the dilute hydrochloric acid with a burette instead of a measuring cylinder would be an improvement.

....

.... [1]

(ii) Explain why it is **not** possible to use a volumetric pipette to measure the volume of aqueous sodium thiosulfate in each experiment.

....

.... [1]

(f) Explain why it is important **not** to change the size of the beaker to a larger beaker during the investigation.

....

....

.... [2]

[Total: 18]

19 Which statements explain why increasing the temperature in a reaction involving gases increases the rate of reaction?

1 It increases the collision frequency between the gas particles.

2 It lowers the activation energy.

3 It increases the kinetic energy of the gas particles.

4 It increases the number of gas particles per unit volume.

A 1 and 3 **B** 1 and 4 **C** 2 and 3 **D** 2 and 4

IGCSE CHEMISTRY • EXERCISE SHEET

6.3 Reversible reactions and equilibrium

Name: ____________ Class: ________ Date: __________ **Total: 10 marks**

KEY WORDS equilibrium 平衡 • reverse reaction 逆反应 • haber 哈伯法 • contact 接触法 • reversible reaction 可逆

Objective

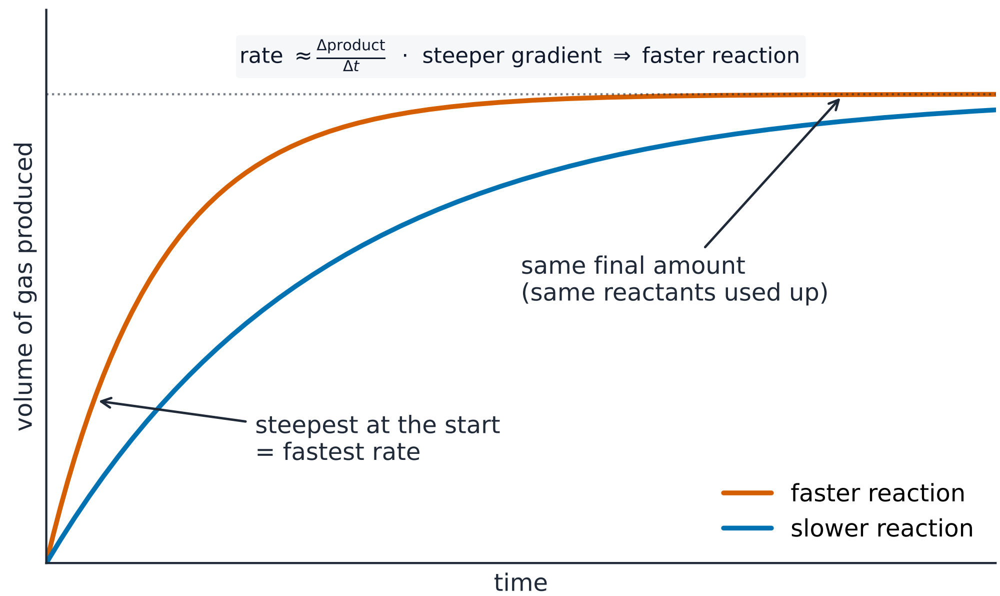
Build the skills to answer exam questions on **reversible reactions and equilibrium 可逆反应与平衡** — the ⇌ symbol, **equilibrium 平衡**, moving the position, and the **Haber 哈伯法** and **Contact 接触法** processes.

You must be able to:

- describe a reversible reaction (e.g. hydrated/anhydrous salts)
- state the conditions for equilibrium in a closed system
- predict how temperature/pressure/concentration shift the equilibrium

1 Worked examples

■ Equilibrium and the Haber process



At equilibrium the forward and reverse rates are equal and concentrations stop changing

- **Haber:** $N_2 + 3H_2 \rightleftharpoons 2NH_3$; ~450 °C, ~200 atm, iron catalyst.
- **shifts:** more pressure → side with fewer gas molecules; add a substance → moves to use it up.
- a **catalyst** does **not** shift the position — only speeds up reaching equilibrium.

2 Practice

2.1 State the two conditions for a reaction at equilibrium. [2]

2.2 Give the catalyst used in the Haber process. [1]

3 Exam-style questions

3.1 Adding a catalyst to a reaction at equilibrium: [1]

- **A** moves the equilibrium to the products
- **B** moves it to the reactants
- **C** does not move the position, but reaches equilibrium faster
- **D** stops the reaction

3.2 In the Haber process $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$.

(a) State the effect of increasing the pressure on the amount of ammonia. [2]

(b) Explain why a temperature of about 450 °C is used, even though a lower temperature would give more ammonia. [2]

3.3 Anhydrous copper(II) sulfate is white; adding water turns it blue. State what this is used to test for, and why this is a reversible reaction. [2]

Solutions

2.1 the forward and reverse reactions occur at the same rate; the concentrations of reactants and products stay constant.

2.2 iron.

3.1 C. A catalyst does not change the position; it only speeds up reaching equilibrium.

3.2 (a) the amount of ammonia increases; because the equilibrium moves to the side with fewer gas molecules (2 vs 4).
(b) a lower temperature gives more ammonia but the reaction is too slow; 450 °C is a compromise that keeps a good rate.

3.3 it tests for water; the reaction can go both ways — losing water (heating) and gaining it again.

17 Which equation represents one of the reactions in the Contact process?

A $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$

B $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(aq)$

C $2SO_3(g) + O_2(g) \rightleftharpoons 2SO_4(aq)$

D $2SO_3(g) + O_2(g) \rightleftharpoons 2SO_4(g)$

19 In the Haber process, nitrogen and hydrogen react to form ammonia.

$$N_2 + 3H_2 \rightleftharpoons 2NH_3$$

The forward reaction is exothermic.

Which changes in pressure and temperature increase the yield of ammonia?

	change in pressure	change in temperature
A	decrease	decrease
B	decrease	increase
C	increase	decrease
D	increase	increase

18 The equation shows the equilibrium between dinitrogen tetroxide, N_2O_4, and nitrogen dioxide, NO_2.

The colours of the reactant and product are shown.

$$\underset{\text{colourless}}{N_2O_4(g)} \rightleftharpoons \underset{\text{brown}}{2NO_2(g)}$$

The forward reaction is endothermic.

Which statement is **not** correct?

A At equilibrium, the concentrations of the reactant and the product stay constant.

B At equilibrium, the rate of the forward reaction is equal to the rate of the reverse reaction.

C When the pressure is increased, a darker brown colour is seen.

D When the temperature is increased, a darker brown colour is seen.

19 Ethanol is manufactured by the addition of steam to ethene.

$$C_2H_4(g) + H_2O(g) \rightleftharpoons C_2H_5OH(g)$$

The reaction conditions are 300 °C and 60 atm.

The forward reaction is exothermic.

Which rows describe the effect on the equilibrium yield of C_2H_5OH when the stated change is made?

	change	equilibrium yield of C_2H_5OH
1	adding a catalyst	no change
2	decreasing the temperature	increases
3	decreasing the pressure	increases

A 1 and 2 **B** 1 and 3 **C** 2 only **D** 3 only

20 Which row identifies the conditions used to make sulfur trioxide in the Contact process?

	pressure / kPa	catalyst
A	200	iron
B	200	vanadium(V) oxide
C	20 000	iron
D	20 000	vanadium(V) oxide

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

$$SF_4(g) + 2H_2O(g) \rightleftharpoons SO_2(g) + 4HF(g) \qquad \Delta H = -54\,\text{kJ/mol}$$

(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.

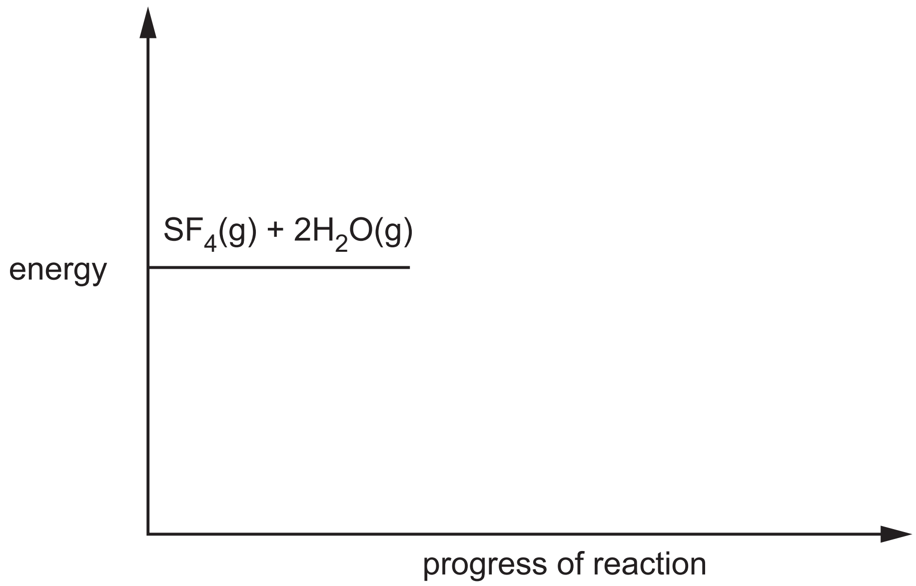
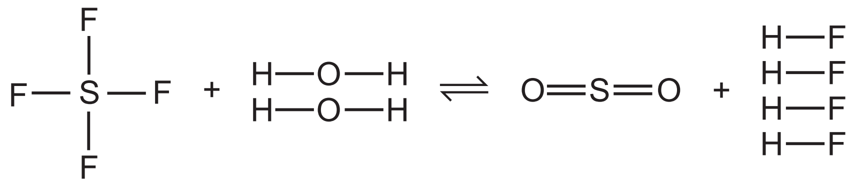


Fig. 4.1

[4]

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



$\Delta H = -54\,kJ/mol$

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]

(c) The equation for the reaction is shown.

$$SF_4(g) + 2H_2O(g) \rightleftharpoons SO_2(g) + 4HF(g) \qquad \Delta H = -54\,kJ/mol$$

State the effect, if any, on the position of equilibrium when the following changes are made.

Give a reason for each of your answers.

- The temperature is increased.

....

....

- The pressure is increased.

....

....

- A catalyst is added.

....

....

[5]

(d) Explain, in terms of collision theory, why reducing the temperature decreases the rate of the reverse reaction.

....

....

....

....

.... [3]

[Total: 16]

Question 5 starts on the next page.

16 Industrially, ammonia is made by the Haber process. The equation is shown.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \qquad \Delta H = -92\,kJ/mol$$

The conditions used are 450 °C and 200 atm.

Which statements about the conditions are correct?

1 Temperatures below 450 °C give a lower rate of reaction.

2 Temperatures below 450 °C give a lower yield of ammonia.

3 Pressures above 200 atm give a lower yield of ammonia.

4 Pressures above 200 atm are too expensive to maintain.

A 1 and 2 **B** 1 and 4 **C** 2 and 3 **D** 3 and 4

16 The reaction between aqueous iron(III) ions, Fe^{3+}, and aqueous thiocyanate ions, SCN^-, is reversible.

The equation for the reaction is shown.

$$\underset{\text{yellow}}{Fe^{3+}(aq)} + \underset{\text{colourless}}{SCN^-(aq)} \rightleftharpoons \underset{\text{red}}{FeSCN^{2+}(aq)}$$

At equilibrium, the concentrations of Fe^{3+} ions, SCN^- ions, and $FeSCN^{2+}$ ions are identical, and the mixture appears orange.

When a few drops of aqueous thiocyanate ions are added to the mixture, a new equilibrium forms.

How does the colour of the mixture change?

A It becomes colourless.

B It becomes a lighter orange.

C It becomes more yellow.

D It becomes more red.

5 Methanol, CH_3OH, is manufactured by the reaction between hydrogen and carbon monoxide.

An equilibrium mixture is produced.

$$2H_2(g) + CO(g) \rightleftharpoons CH_3OH(g)$$

(a) State what happens to the concentration of CH_3OH when the reaction is at equilibrium.

Explain your answer in terms of rate of forward and reverse reactions.

....

....

.... [2]

(b) The reaction is carried out at a pressure of 75 atmospheres and a temperature of 250 °C.

(i) State **two** disadvantages of using a pressure **below** 75 atmospheres.

1 ....

2 ....
[2]

(ii) Complete Table 5.1 using **only** the words **increases**, **decreases** or **no change**.

Table 5.1

	effect on the concentration of $CH_3OH(g)$ at equilibrium	effect on the rate of the reverse reaction
catalyst is added		

[2]

(iii) If a temperature of more than 250 °C is used, the yield of methanol decreases.

State what can be deduced about the forward reaction.

.... [1]

(iv) Suggest which of the elements from the list is a suitable catalyst for the reaction. Give a reason for your answer.

barium **carbon** **copper** **potassium** **sulfur**

catalyst ....

reason ....
[2]

(c) Methanol is a member of the homologous series of alcohols.

(i) State **two** characteristics of all members of a homologous series.

1 ....

2 ....
[2]

(ii) State the molecular formula of an alcohol that contains five carbon atoms.

.... [1]

(d) Carboxylic acids react with alcohols to form esters.

(i) Draw the displayed formula of an ester which contains three carbon atoms.

[2]

(ii) Butyl ethanoate is an ester.

Name the alcohol and the carboxylic acid that react to produce butyl ethanoate.

alcohol ....

carboxylic acid ....
[2]

(e) An organic compound has the following composition by mass:

C, 64.87%; H, 13.51%; O, 21.62%.

Calculate the empirical formula of the compound.

empirical formula = ... [2]

[Total: 18]

20 The equation for the reaction between ammonia and oxygen is shown.

$$4NH_3(g) + 5O_2(g) \rightleftharpoons 4NO(g) + 6H_2O(g) \qquad \Delta H = -909\,kJ/mol$$

Which two changes to the reaction conditions will **both** move the position of equilibrium to the right?

	change 1	change 2
A	increasing the temperature	decreasing the pressure
B	increasing the temperature	increasing the pressure
C	decreasing the temperature	increasing the pressure
D	decreasing the temperature	decreasing the pressure

6.4 Redox

Name: ____________ Class: ________ Date: __________ **Total: 8 marks**

KEY WORDS oxidation 氧化 • electrons 电子 • reducing agent 还原剂 • reduction 还原 • oxidising agent 氧化剂

Objective

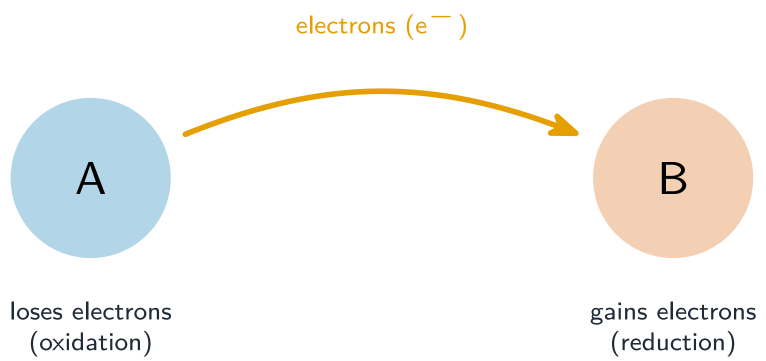
Build the skills to answer exam questions on **redox 氧化还原** — oxidation and reduction in terms of oxygen and **electrons 电子**, **oxidising/reducing agents 氧化剂/还原剂**, and colour tests.

You must be able to:

- define oxidation and reduction (oxygen, electrons — OIL RIG)
- identify the oxidising agent and the reducing agent
- use the colour changes of manganate(VII) and iodide

1 Worked examples

Electron transfer



OIL RIG: Oxidation Is Loss, Reduction Is Gain (of electrons) — they always happen together

- **oxidation:** loss of electrons (or gain of oxygen); **reduction:** gain of electrons (or loss of oxygen).
- **oxidising agent:** is itself reduced; **reducing agent:** is itself oxidised.
- acidified manganate(VII) (purple) → colourless when it acts as an oxidising agent.

2 Practice

2.1 Define oxidation in terms of electrons. [1]

2.2 State the colour change of acidified potassium manganate(VII) when it is reduced. [1]

3 Exam-style questions

3.1 In the reaction $Zn + Cu^{2+} \rightarrow Zn^{2+} + Cu$, the zinc is: [1]

- **A** reduced (gains electrons)
- **B** oxidised (loses electrons)
- **C** the oxidising agent
- **D** unchanged

3.2 Consider $Mg + CuO \rightarrow MgO + Cu$.

(a) State which substance is oxidised and which is reduced (using oxygen). [2]

(b) Name the reducing agent. [1]

3.3 Explain why oxidation and reduction must always happen together in a redox reaction. [2]

Solutions

2.1 the loss of electrons.

2.2 from purple to colourless.

3.1 B. Zinc loses electrons to become Zn^{2+} — it is oxidised.

3.2 (a) magnesium is oxidised (gains oxygen); copper oxide is reduced (loses oxygen).
(b) magnesium.

3.3 electrons lost by one substance must be gained by another; so when one is oxidised, another is reduced at the same time.

18 The ionic equation for the redox reaction between acidified manganate(VII) ions and iodide ions is shown.

$$2MnO_4^-(aq) + 16H^+(aq) + 10I^-(aq) \rightarrow 2Mn^{2+}(aq) + 5I_2(aq) + 8H_2O(l)$$

Which row shows the changes in oxidation number for manganese and for iodine during this reaction?

	manganese		iodine	
	from	to	from	to
A	–2	+4	–1	0
B	–2	+4	–10	+5
C	+7	+2	–1	0
D	+7	+2	–10	+5

IGCSE Chemistry: **w25 22**

19 What is the oxidation number of chromium in the $Cr_2O_7^{2-}$ ion?

A –2 **B** –1 **C** +6 **D** +12

IGCSE Chemistry: **w25 23**

18 Zinc reacts with dilute hydrochloric acid.

Which statement about the particles in the reaction is correct?

A Increasing the concentration of dilute hydrochloric acid increases the collision rate but has **no** effect on the activation energy.

B Increasing the concentration of dilute hydrochloric acid increases the collision rate and the activation energy.

C Increasing the temperature of the reaction increases the activation energy.

D Increasing the temperature of the reaction causes all collisions to lead to a reaction.

22 The equation shows the reaction between copper and concentrated nitric acid.

$$Cu(s) + 4HNO_3(aq) \rightarrow Cu(NO_3)_2(aq) + 2NO_2(g) + 2H_2O(l)$$

Which element is reduced in this reaction?

A oxygen

B nitrogen

C copper

D hydrogen

2 Iron is extracted from iron ore in a blast furnace.

(a) The iron compound in the main iron ore used in the blast furnace is iron(III) oxide.

(i) State the name of the main iron ore used in the blast furnace.

.... [1]

(ii) State how the main source of heat is provided in the blast furnace.

.... [1]

(iii) Name the gaseous reducing agent in the blast furnace.

.... [1]

(iv) Write a symbol equation for the reduction of iron(III) oxide by the gaseous reducing agent in **(a)(iii)**.

.... [2]

(v) The main impurity in iron ore is silicon(IV) oxide.

Write **two** symbol equations to show the role of limestone in removing silicon(IV) oxide from iron ore.

1 ....

2 ....

[2]

(b) Table 2.1 shows four different isotopes of iron, **A**, **B**, **C** and **D**.

Table 2.1

A	B	C	D
^{54}Fe	^{56}Fe	^{57}Fe	^{58}Fe

Explain why **A**, **B**, **C** and **D** are isotopes of iron.

....

.... [2]

(c) Iron can form two different ions, Fe^{2+} and Fe^{3+}.

(i) Complete Table 2.2 to show the number of protons, neutrons and electrons in the two iron ions shown.

Table 2.2

	$^{54}Fe^{2+}$	$^{58}Fe^{3+}$
protons		
neutrons		
electrons		

[3]

(ii) Describe a test for aqueous Fe^{2+} ions.

test ....

observations ....

.... [2]

(d) An oxidising agent converts Fe^{2+} ions to Fe^{3+} ions.

(i) Define the term oxidising agent.

....

.... [2]

(ii) Explain why the conversion of Fe^{2+} ions to Fe^{3+} ions is described as oxidation.

.... [1]

(iii) The oxidising agent for the conversion of Fe^{2+} ions to Fe^{3+} ions is aqueous potassium manganate(VII).

State **one** condition needed for the oxidation to take place.

.... [1]

(e) Iodide ions, I^-, reduce Fe^{3+} ions to Fe^{2+} ions in aqueous solution.

Suggest the identity of the other product formed in this reaction.

.... [1]

[Total: 19]

17 Which equations show the underlined species acting as a reducing agent?

1 $\underline{Fe_2O_3} + 3CO \rightarrow 2Fe + 3CO_2$

2 $\underline{Fe} + CuSO_4 \rightarrow FeSO_4 + Cu$

3 $\underline{5Fe^{2+}} + MnO_4^- + 8H^+ \rightarrow 5Fe^{3+} + Mn^{2+} + 4H_2O$

4 $\underline{Fe(OH)_2} + H_2SO_4 \rightarrow FeSO_4 + 2H_2O$

A 1 and 2 **B** 1 and 4 **C** 2 and 3 **D** 3 and 4

IGCSE Chemistry: **s25 23**

18 The equation represents a redox reaction.

$$2Al + Fe_2O_3 \rightarrow 2Fe + Al_2O_3$$

What is the change in the oxidation number of iron in this reaction?

A from +2 to +3

B from +2 to 0

C from +3 to +2

D from +3 to 0

IGCSE Chemistry: **m25 22**

21 Mercury(II) oxide, HgO, decomposes when heated.

The equation is shown.

$$2HgO \rightarrow 2Hg + O_2$$

Why is this a reduction reaction?

A The products weigh less than the reactants.

B There are fewer reactants than products.

C There is a gain of oxygen.

D There is a loss of oxygen.