Week 10

A-Level Chemistry

Homework bundle for this week
本周作业合集

exercises.lol

Contents 目录

A-Level Chemistry Name: ____________ Score: ______

1. A reversible reaction is one that:
   - ☐ can go both forwards and backwards
   - ☐ only goes forwards
   - ☐ never reaches equilibrium
   - ☐ gives off no energy
2. Le Chatelier's principle says that a change to a system at equilibrium causes it to:
   - ☐ shift to oppose (reduce) that change
   - ☐ shift to increase that change
   - ☐ stop reacting
   - ☐ explode
3. In the expression for Kc, the concentrations of the products are:
   - ☐ on the top, raised to the powers from the equation
   - ☐ on the bottom
   - ☐ ignored
   - ☐ added to the reactants
4. The Haber process makes:
   - ☐ ammonia, from nitrogen and hydrogen
   - ☐ sulfur trioxide
   - ☐ sulfuric acid
   - ☐ oxygen
5. In the Brønsted–Lowry theory, an acid is a:
   - ☐ proton donor
   - ☐ proton acceptor
   - ☐ electron donor
   - ☐ electron acceptor
6. A closed system is needed to reach equilibrium.

   ☐ True ☐ False

7. Kp is written using partial pressures rather than concentrations.

☐ True ☐ False

8. At dynamic equilibrium the forward and backward reactions occur at equal rates.

☐ True ☐ False

9. Increasing the pressure shifts equilibrium towards the side with fewer gas molecules.

☐ True ☐ False

10. The equilibrium constant in terms of concentrations is written as _________.

____

7. Equilibria

A-Level Chemistry

1. **can go both forwards and backwards**

   A reversible reaction ($\rightleftharpoons$) can form products and turn them back into reactants.

2. **shift to oppose (reduce) that change**

   The equilibrium position always moves in the direction that lessens the change you made.

3. **on the top, raised to the powers from the equation**

   Kc = [products]^powers / [reactants]^powers, with the powers taken from the balanced equation.

4. **ammonia, from nitrogen and hydrogen**

   The Haber process makes ammonia: $N_2 + 3H_2 \rightleftharpoons 2NH_3$ (exothermic).

5. **proton donor**

   A Brønsted–Lowry acid donates a proton (H^+); a base accepts one.

6. **True**

   If the system were open, products could escape and the forward and reverse rates could never balance.

7. **True**

   For gas-phase equilibria, Kp uses the partial pressures of the gases.

8. **True**

   Concentrations stay constant.

9. **True**

   Le Chatelier's principle.

10. **Kc**

    Kc = products over reactants, each raised to its mole number.

A-LEVEL CHEMISTRY • EXERCISE SHEET

7.1 Chemical equilibria: reversible reactions and dynamic equilibrium

Name: ____________ Class: ________ Date: __________ **Total: 11 marks**

KEY WORDS equilibrium 平衡 • equilibrium constant 平衡常数 • dynamic equilibrium 动态平衡 • partial pressure 分压 • haber 哈伯法

Objective

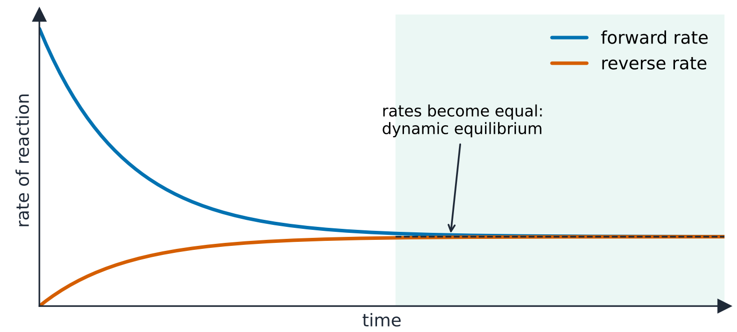
Build the skills to answer exam questions on **chemical equilibria** — **dynamic equilibrium 动态平衡**, **Le Chatelier's principle 勒夏特列原理**, the equilibrium constants K_c and K_p, and the **Haber 哈伯法** process.

You must be able to:

- explain dynamic equilibrium and use Le Chatelier's principle
- write K_c and K_p expressions and use partial pressures
- carry out equilibrium calculations and explain the Haber/Contact conditions

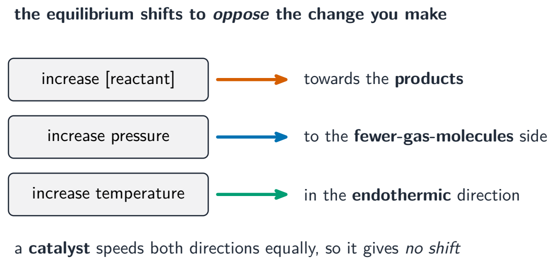
1 Worked examples

■ Dynamic equilibrium and Le Chatelier



at equilibrium: rate$_f$ = rate$_r$ · $K_c = \frac{\text{[products]}}{\text{[reactants]}}$ (stoich. powers)

At dynamic equilibrium the forward and reverse rates are equal, so concentrations stay constant (closed system)

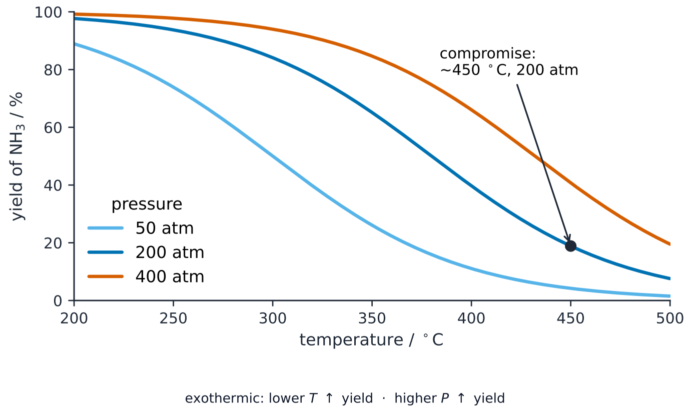


Le Chatelier: the equilibrium shifts to oppose a change. ↑[reactant]→products; ↑pressure→fewer gas molecules; ↑temperature→endothermic direction; catalyst→no shift

■ Equilibrium constants

For aA + bB ⇌ cC + dD: $K_c = \frac{[\mathrm{C}]^c[\mathrm{D}]^d}{[\mathrm{A}]^a[\mathrm{B}]^b}$. **Example.** $H_2 + I_2 \rightleftharpoons 2HI$ with $[H_2]=[I_2]=0.20$, $[HI]=1.6$: $K_c = \frac{1.6^2}{0.20 \times 0.20} = 64$ (no units). Partial pressure = mole fraction × total pressure → K_p. **Only temperature changes K.**

■ **The Haber process**



Haber ($N_2 + 3H_2 \rightleftharpoons 2NH_3$, exothermic): more NH_3 at low T, high p; ~450 °C, 200 atm, Fe catalyst is the compromise

2 Practice

2.1 State the **two** features of a system at dynamic equilibrium. [2]

2.2 Write the K_c expression for $N_2 + 3H_2 \rightleftharpoons 2NH_3$. [1]

3 Exam-style questions

3.1 For an **exothermic** equilibrium, increasing the temperature: [1]

- **A** shifts it towards the products
- **B** shifts it towards the reactants (the endothermic direction)
- **C** has no effect
- **D** increases the value of K_c towards products

3.2 Adding a catalyst to a system at equilibrium: [1]

- **A** shifts it towards the products
- **B** shifts it towards the reactants
- **C** does not change the position of equilibrium
- **D** increases K_c

3.3 At equilibrium, $N_2O_4 \rightleftharpoons 2NO_2$ has $[N_2O_4] = 0.10$ and $[NO_2] = 0.20$ mol dm^{-3}.

(a) Write the expression for K_c and calculate its value (give units). [3]

(b) State the effect on the **value** of K_c of increasing the pressure. [1]

3.4 A gas mixture contains 3.0 mol of SO_2 and 1.0 mol of O_2 at a total pressure of 400 kPa. Calculate the partial pressure of SO_2. [2]

Solutions

2.1 the forward and reverse rates are equal; the concentrations of reactants and products stay constant.

2.2 $K_c = \dfrac{[NH_3]^2}{[N_2][H_2]^3}$.

3.1 B. Raising T shifts an exothermic equilibrium towards the reactants (endothermic direction).

3.2 C. A catalyst speeds both directions equally — no shift.

3.3 (a) $K_c = \dfrac{[NO_2]^2}{[N_2O_4]} = \dfrac{0.20^2}{0.10} = 0.40$ mol dm^{-3}.
(b) no change — only temperature changes K_c.

3.4 total moles = 4.0; mole fraction of SO_2 = 3.0/4.0 = 0.75; $p(SO_2) = 0.75 \times 400 =$ 300 kPa.

12 One molecule of haemoglobin, Hb, can bind with four molecules of oxygen according to the equation shown.

$$Hb(aq) + 4O_2(aq) \rightleftharpoons Hb(O_2)_4(aq)$$

When the equilibrium concentration of O_2 is 7.6×10^{-6} mol dm^{-3}, the equilibrium concentrations of Hb and $Hb(O_2)_4$ are equal.

What is the numerical value of K_c for this equilibrium?

A 3.0×10^{20} **B** 1.3×10^{5} **C** 7.6×10^{-6} **D** 3.3×10^{-21}

12 An equilibrium can be represented by the equation shown.

$$P(aq) + Q(aq) \rightleftharpoons 2R(aq) + S(aq)$$

In a certain mixture, of volume 1.0 dm^3, the equilibrium concentration of Q is 10 mol dm^{-3}.

What will be the new equilibrium concentration of Q if 5.0 mol of pure Q is completely dissolved in the mixture?

A 15 mol dm^{-3}

B between 10 mol dm^{-3} and 15 mol dm^{-3}

C 10 mol dm^{-3}

D between 5.0 mol dm^{-3} and 10 mol dm^{-3}

13 In the Contact process, sulfur dioxide and oxygen react to form sulfur trioxide.

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

Which statement about these processes is correct?

A K_p for the Haber process has no unit.

B In the Contact process, the value of K_p falls when pressure is increased at constant T.

C The Haber process uses a homogeneous catalyst.

D When V_2O_5 is used in the Contact process, the position of equilibrium is unchanged.

12 Nitrogen dioxide decomposes on heating according to the equation shown.

$$2NO_2(g) \rightleftharpoons 2NO(g) + O_2(g)$$

When 4 mol of nitrogen dioxide were put into a 1 dm^3 container and heated to a constant temperature, the equilibrium mixture contained 0.8 mol of oxygen.

What is the value of the equilibrium constant, K_c, at the temperature of the experiment?

A $\dfrac{0.8^2 \times 0.8}{4^2}$ **B** $\dfrac{1.6 \times 0.8}{2.4^2}$ **C** $\dfrac{1.6^2 \times 0.8}{4^2}$ **D** $\dfrac{1.6^2 \times 0.8}{2.4^2}$

13 One particle of X reacts with one particle of Y in a single-step reaction to produce two particles of Z.

This reaction is exothermic and reversible.

$$X + Y \rightleftharpoons 2Z$$

Three statements about the forward and reverse reactions are listed.

1 The activation energy of the forward reaction is equal to the activation energy of the reverse reaction.

2 At equilibrium, the frequency of collisions between one particle of X and one particle of Y is equal to the frequency of collisions between two particles of Z.

3 At equilibrium, the frequency of effective collisions between one particle of X and one particle of Y is equal to the frequency of effective collisions between two particles of Z.

Which statements are correct?

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

1 Aqueous silver ions, $Ag^+(aq)$, react slowly with aqueous iron(II) ions, $Fe^{2+}(aq)$. An equilibrium is established.

$$Ag^+(aq) + Fe^{2+}(aq) \rightleftharpoons Ag(s) + Fe^{3+}(aq)$$

The concentration of $Ag^+(aq)$ at equilibrium can be determined by titration with a standard solution of aqueous potassium thiocyanate, KSCN(aq).

During the titration, the remaining $Ag^+(aq)$ ions react with $SCN^-(aq)$ ions to form a precipitate of AgSCN(s).

$$Ag^+(aq) + SCN^-(aq) \rightarrow AgSCN(s)$$

When all $Ag^+(aq)$ ions have been removed from solution, excess $SCN^-(aq)$ ions react with $Fe^{3+}(aq)$ to form a complex ion, $FeSCN^{2+}(aq)$, which has a red colour.

$$Fe^{3+}(aq) + SCN^-(aq) \rightarrow FeSCN^{2+}(aq)$$

The appearance of the red colour indicates the end-point.

A student carries out an experiment to determine the equilibrium constant, K_c.

$$K_c = \frac{[Fe^{3+}(aq)]_{eqm}}{[Fe^{2+}(aq)]_{eqm}\,[Ag^+(aq)]_{eqm}}$$

The student makes 250.0 cm^3 of 0.0200 mol dm^{-3} KSCN(aq) to use in the titration.

(a) Calculate the mass of solid potassium thiocyanate, KSCN(s), needed to make 250.0 cm^3 of 0.0200 mol dm^{-3} KSCN(aq).

mass of KSCN(s) = ... g [1]

(b) Describe how the student should make 250.0 cm^3 of 0.0200 mol dm^{-3} KSCN(aq) starting from the mass of KSCN(s) calculated in **(a)** in a 50 cm^3 beaker.

Give the name and size of any key apparatus used.

Write your answer using a series of numbered steps.

....

....

....

....

....

....

.... [3]

(c) The student uses the following method to determine K_c.

step 1 Add 25.0 cm^3 of 0.100 mol dm^{-3} aqueous silver nitrate, $AgNO_3$(aq), into a dry conical flask. Label this flask **A**.

step 2 Add 25.0 cm^3 of 0.100 mol dm^{-3} aqueous iron(II) sulfate, $FeSO_4$(aq), into flask **A**.

step 3 Seal flask **A**, using a bung.

step 4 Allow flask **A** to stand for twelve hours.

step 5 Transfer 10.0 cm^3 of the mixture from flask **A** into another conical flask, flask **B**, without disturbing the precipitate in flask **A**.

step 6 Titrate the sample in flask **B** with 0.0200 mol dm^{-3} aqueous potassium thiocyanate, KSCN(aq).

step 7 Repeat steps 5 and 6 until concordant values are obtained.

(i) Suggest why flask **A** is sealed with a bung in step 3.

....

.... [1]

(ii) Suggest why flask **A** is left to stand for twelve hours in step 4.

....

.... [1]

(iii) Identify the precipitate in flask **A** in step 5.

[1]

(d) The student's results are shown in Table 1.1

Table 1.1

	rough titration	titration 1	titration 2	titration 3
final burette reading / cm^3	22.50	21.75	31.65	32.20
initial burette reading / cm^3	0.00	0.00	9.75	10.20
titre / cm^3	22.50	21.75	21.90	22.00

(i) State if concordant titres have been achieved.

Explain your answer.

....

.... [1]

(ii) Calculate the percentage error in the titre volume in titration 2.

Show your working.

percentage error = ... [1]

(iii) The student repeats the experiment using KSCN(aq) at a **higher** concentration. The student obtains **smaller** titres.

Suggest **one** reason why a larger titre is better than a smaller titre.

.... [1]

(e) Another student calculates a mean titre of $21.85\,cm^3$. Use this value to complete the following calculation.

(i) Calculate $[Ag^+(aq)]$ in the equilibrium mixture in flask **A**.

$[Ag^+(aq)]_{eqm}$ = ... $mol\,dm^{-3}$ [1]

(ii) Calculate $[Fe^{3+}(aq)]$ in the equilibrium mixture in flask **A**.

$[Fe^{3+}(aq)]_{eqm}$ = ... $mol\,dm^{-3}$ [1]

(iii) The formula for the equilibrium constant, K_c, is shown.

$$K_c = \frac{[Fe^{3+}(aq)]_{eqm}}{[Fe^{2+}(aq)]_{eqm}\,[Ag^+(aq)]_{eqm}}$$

Determine the value of K_c.

Give the units of K_c.

K_c = ...

units ....
[2]

(f) Several other students perform the same experiment at different temperatures. The K_c values that they obtain are used to produce the graph in Fig. 1.1.

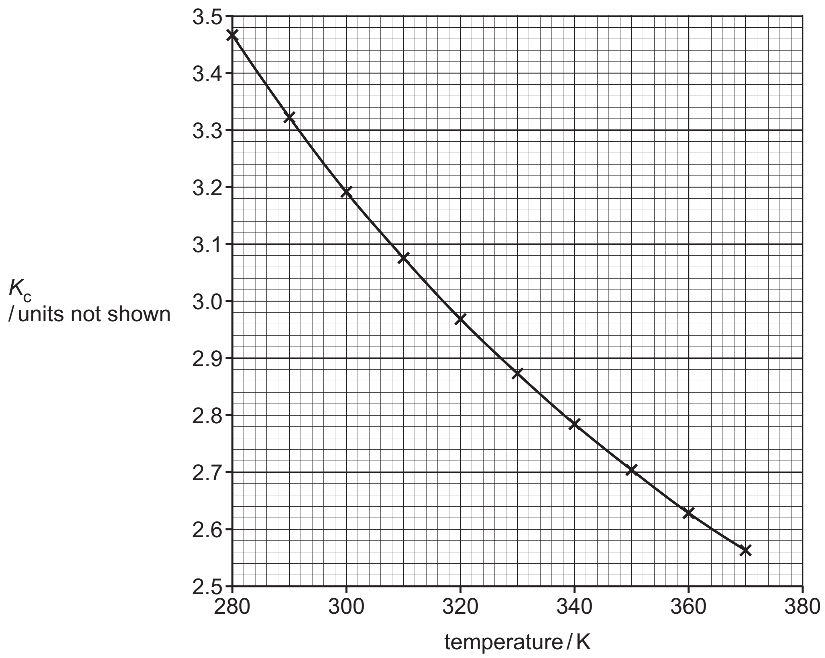


Fig. 1.1

(i) One student suggests that K_c is directly proportional to temperature.

State and explain if the results displayed in Fig. 1.1 support this suggestion.

....

.... [1]

(ii) Another student suggests that the data represented in the graph in Fig. 1.1 is reliable.

Explain how the graph supports this suggestion.

....

....

.... [1]

(iii) Use the data displayed in Fig. 1.1 to state if the forward reaction is exothermic or endothermic.

$$Ag^{+}(aq) + Fe^{2+}(aq) \rightleftharpoons Ag(s) + Fe^{3+}(aq)$$

Explain your answer.

forward reaction ....

explanation ....

....

.... [1]

[Total: 17]

A-LEVEL CHEMISTRY • EXERCISE SHEET

7.2 Brønsted–Lowry theory of acids and bases

Name: ________ Class: ______ Date: ______ **Total: 12 marks**

KEY WORDS acid 酸 • titration curve 滴定曲线 • titration 滴定 • strong acid 强酸 • weak acid 弱酸

Objective

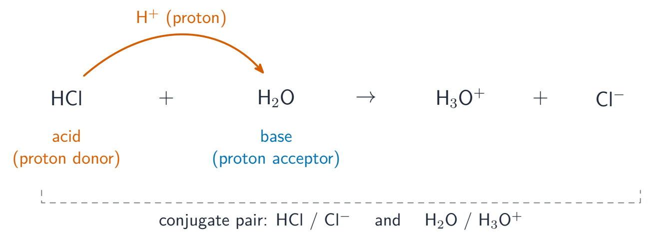
Build the skills to answer exam questions on the **Brønsted–Lowry theory** 布朗斯特-劳里理论 — proton donors and acceptors, **strong and weak** 强弱 acids/bases, **neutralisation** 中和, and titration curves.

You must be able to:

- describe the Brønsted–Lowry theory and name the common acids and alkalis
- explain strong vs weak acids and how to tell them apart
- sketch titration curves and select a suitable indicator

1 Worked examples

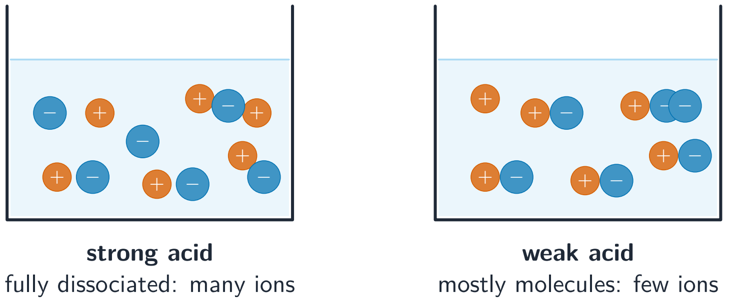
■ Brønsted–Lowry acids and bases



An acid is a proton (H^+) donor; a base is a proton acceptor — making two conjugate acid–base pairs

Common acids: HCl, H_2SO_4, HNO_3, CH_3COOH. Common alkalis: NaOH, KOH, NH_3.

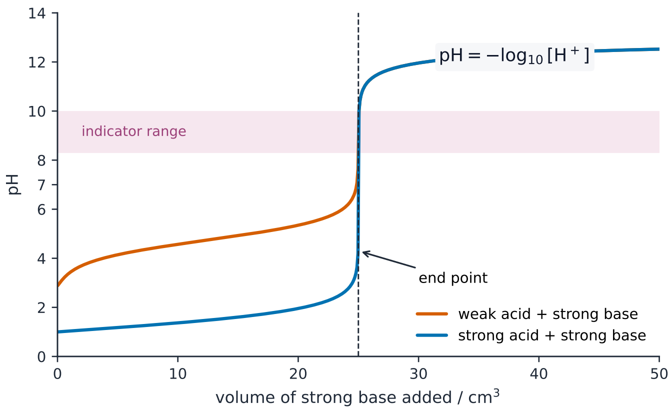
Strong vs weak



A strong acid is fully dissociated; a weak acid is only partly dissociated (not about concentration)

A strong acid has a **lower pH**, fizzes faster with a metal, and conducts better than a weak acid of the same concentration. **Neutralisation:** $H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$, forming a **salt** 盐.

Titration curves and indicators



Choose an indicator whose colour change falls inside the steep pH jump

2 Practice

2.1 Define a Brønsted–Lowry **acid** and **base**. [2]

2.2 State the difference between a strong acid and a weak acid. [2]

3 Exam-style questions

3.1 In the Brønsted–Lowry theory, a base is a: [1]

- **A** proton donor
- **B** proton acceptor
- **C** electron donor
- **D** electron acceptor

3.2 Compared with a weak acid of the same concentration, a strong acid has a: [1]

- **A** higher pH
- **B** lower pH and more ions
- **C** smaller volume
- **D** larger molar mass

3.3 (a) Write the ionic equation for the neutralisation of an acid by an alkali. [1]

(b) Explain why a strong acid conducts electricity better than a weak acid of the same concentration. [2]

3.4 Explain how you would use a pH meter and a reactive metal to show that hydrochloric acid is a stronger acid than ethanoic acid of the same concentration. [3]

Solutions

2.1 an acid is a proton (H^+) donor; a base is a proton acceptor.

2.2 a strong acid is fully dissociated into ions in water; a weak acid is only partly dissociated.

3.1 B. A base is a proton acceptor.

3.2 B. A strong acid is fully dissociated, giving more ions and a lower pH.

3.3 (a) $H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$.
(b) a strong acid is fully dissociated, so has more ions; more ions carry more charge, so it conducts better.

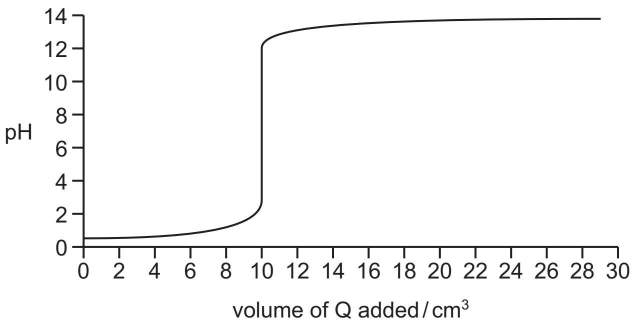
3.4 measure the pH of each with a pH meter — HCl gives a lower pH; add the same reactive metal to each — HCl fizzes faster; both show HCl has more H^+ ions / is more dissociated, so it is stronger.

13 Aqueous acid P and aqueous alkali Q have the same concentration.

$20\,cm^3$ of P is added to a conical flask.

Q is slowly added to the flask and the volume of Q and the pH are recorded.

The pH titration curve is shown.



Which row gives the identity of P and Q?

	P	Q
A	HCl	$NaOH$
B	H_2SO_4	NH_3
C	HCl	$Ba(OH)_2$
D	CH_3COOH	$Sr(OH)_2$

14 Photochromic glass, used for sunglasses, darkens when exposed to bright light and becomes more transparent again when the light is less bright. The darkness of the glass is due to the presence of silver atoms.

The following reactions are involved.

reaction 1 $Ag^+ + Cl^- \rightleftharpoons Ag + Cl$

reaction 2 $Cu^+ + Cl \rightarrow Cu^{2+} + Cl^-$

reaction 3 $Cu^{2+} + Ag \rightarrow Cu^+ + Ag^+$

Which statement about these reactions is correct?

A Cu^+ and Cu^{2+} ions act as catalysts.

B Cu^+ ions act as an oxidising agent in reaction 2.

C Reaction 3 increases the darkness of the glass.

D Silver atoms are reduced in reaction 3.