Unit 8 · Chemical Reaction

ANSWER KEY · FOR TEACHERS

Full marks 45

Give the marks for the points in the marking scheme; an answer in other words that says the same is right.

1 Key words

1. precipitate
2. hydrolysis
3. catalyst
4. enzymes
5. photochemical reaction
6. oxidation
7. polymer
8. degree of polymerization

K · 4

Each carries 0.5 mark.

2 Multiple choice

i. **d.** nylon — K · 1

Nylon is made from a diamine and a dicarboxylic acid, giving off water at each link. The other three are addition polymers of monomers with C=C.

ii. **c.** it is the salt of a weak acid and a strong base, and it hydrolyzes — U · 1

Sodium carbonate comes from weak carbonic acid and strong sodium hydroxide. Its hydrolysis leaves more OH^- than H^+ ions in the water.

iii. **c.** it increases the amount of product formed — U · 1

A catalyst changes only how fast the product forms, never how much: the amount is fixed by the reactants and the equation. That is the point of the potassium chlorate example above.

iv. **a.** CuO — A · 1

Copper oxide gives its oxygen to hydrogen, so it oxidizes the hydrogen; copper oxide itself is reduced. Hydrogen is the reducing agent.

v. **b.** 1,500 — A · 1

The repeating unit, C_2H_4, is 28 g/mol: n = 42,000 ÷ 28 = 1,500.

3 Label the diagram

1. AgCl white
2. $BaSO_4$ white
3. $Cu(OH)_2$ pale blue
4. PbI_2 yellow

K · 4

Each carries 1 mark.

4 Very short answers

a. MARKING SCHEME — K · 1

✓ $Ag^+ + Cl^- \rightarrow AgCl$.

b. MARKING SCHEME — U · 1

✓ Light decomposes them; brown glass keeps it out.

c. MARKING SCHEME — A · 1

✓ Neutral.

d. MARKING SCHEME — K · 1

✓ Isoprene, C_5H_8.

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5 Short answers

a. MARKING SCHEME U · 2

- ✓ It is the salt of a strong acid and a weak base: $NH_4Cl + H_2O \rightleftharpoons NH_4OH + HCl$.
- ✓ The HCl is fully ionized and the NH_4OH mostly not, so there are more H^+ than OH^- ions.

b. MARKING SCHEME U · 2

- ✓ Electrons lost by one substance must be gained by another (oxygen too must come from something).
- ✓ So oxidation of one means reduction of another, at the same time: a redox reaction.

c. MARKING SCHEME A · 2

- ✓ Raw rubber turns soft and sticky when hot, hard and brittle when cold, and wears quickly.
- ✓ Sulphur bridges link the chains so they can't slide apart, so it stays elastic and lasts.

d. MARKING SCHEME A · 2

- ✓ Polythene is a thermoplastic: it softens when hot.
- ✓ Bakelite is thermosetting, its chains cross-linked into a rigid network, so it stays hard.

6 Long answers

a. ANSWER U · 4

Hydrolysis is a reaction in which a substance reacts with water, the water molecule being split into H and OH, which join the parts of the substance.
Sodium ethanoate is the salt of a weak acid (ethanoic acid) and a strong base (sodium hydroxide):

$$CH_3COONa + H_2O \rightleftharpoons CH_3COOH + NaOH$$

Sodium hydroxide is fully ionized, giving OH^- ions, while ethanoic acid stays mostly un-ionized; OH^- ions are in excess, so the solution is basic.
Sodium chloride is the salt of a strong acid and a strong base. Any HCl and NaOH formed would be fully ionized back into Na^+, Cl^-, H^+ and OH^-, with H^+ and OH^- in equal numbers, so there is no net hydrolysis and the solution is neutral.

MARKING SCHEME

- ✓ Hydrolysis: a substance reacts with water, which is split into H and OH.
- ✓ $CH_3COONa + H_2O \rightleftharpoons CH_3COOH + NaOH$.
- ✓ NaOH is fully ionized and ethanoic acid mostly not, so OH^- is in excess: basic.
- ✓ NaCl comes from a strong acid and a strong base; any HCl and NaOH ionize back fully, with equal H^+ and OH^-: neutral.

b. ANSWER A · 4

$Zn + CuSO_4 \rightarrow ZnSO_4 + Cu$, or as ions, $Zn + Cu^{2+} \rightarrow Zn^{2+} + Cu$ (the sulphate ions take no part).

- $Zn \rightarrow Zn^{2+} + 2e^-$: zinc loses electrons, so it is **oxidized**.
- $Cu^{2+} + 2e^- \rightarrow Cu$: copper ions gain electrons, so they are **reduced**.

The electrons lost by zinc are gained by the copper ions, so oxidation and reduction happen together: it is a redox reaction. Zinc is the reducing agent and Cu^{2+} the oxidizing agent.

MARKING SCHEME

- ✓ $Zn + Cu^{2+} \rightarrow Zn^{2+} + Cu$; the sulphate ions take no part.
- ✓ $Zn \rightarrow Zn^{2+} + 2e^-$: zinc is oxidized.
- ✓ $Cu^{2+} + 2e^- \rightarrow Cu$: copper ions are reduced.
- ✓ The electrons zinc loses are gained by the copper ions, so both happen together; Zn is the reducing agent and Cu^{2+} the oxidizing agent.

7 Numerical problems

a. ANSWER

$n(H_2O_2) = \dfrac{6.8}{34} = 0.2$ mol.

a. 2 mol H_2O_2 give 1 mol O_2, so 0.1 mol O_2: $0.1 \times 22.4 =$ **2.24 L at STP**.

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b. 2 mol H_2O_2 give 2 mol H_2O, so 0.2 mol H_2O: $0.2 \times 18 = \mathbf{3.6\ g}$. A · 4

c. **1 g**: a catalyst is not used up. (Check: 6.8 g of H_2O_2 gave 3.6 g of water and $0.1 \times 32 = 3.2$ g of oxygen, 6.8 g in all.)

MARKING SCHEME

✓ $n(H_2O_2) = 6.8 \div 34 = 0.2$ mol.
✓ 0.1 mol $O_2 = 2.24$ L at STP.
✓ 0.2 mol $H_2O = 3.6$ g.
✓ 1 g of manganese dioxide is left: a catalyst is not used up.

b. **ANSWER** A · 2

Molar mass of the repeating unit, $C_2H_3Cl = 2 \times 12 + 3 \times 1 + 35.5 = 62.5$ g/mol.
Molar mass of PVC $= 1{,}600 \times 62.5 = \mathbf{100{,}000\ g/mol}$.

MARKING SCHEME

✓ The repeating unit $C_2H_3Cl = 62.5$ g/mol.
✓ $1{,}600 \times 62.5 = 100{,}000$ g/mol.

c. **ANSWER** HA · 3

Molar mass of $C_6H_{10}O_5 = 72 + 10 + 80 = 162$ g/mol, so 16.2 g holds $\frac{16.2}{162} = 0.1$ mol of units.

Each unit takes 1 mol of water: $0.1 \times 18 = \mathbf{1.8\ g\ of\ water}$.
Each unit gives 1 mol of glucose ($C_6H_{12}O_6$, 180 g/mol): $0.1 \times 180 = \mathbf{18\ g\ of\ glucose}$.
Check: 16.2 + 1.8 = 18 g. The glucose is heavier than the starch by exactly the water it took in.

MARKING SCHEME

✓ $16.2 \div 162 = 0.1$ mol of repeating units.
✓ $0.1 \times 18 = 1.8$ g of water.
✓ $0.1 \times 180 = 18$ g of glucose.

8 Think

ANSWER HA · 3

Starch (rice) and cellulose (cotton) are both condensation polymers of glucose, but their links are turned differently. Digesting either means hydrolyzing those links back to glucose, and each kind of link needs its own enzyme, because enzymes are specific. Your saliva and gut make amylase, which fits starch's links, but no enzyme for cellulose's links. A cow's stomach holds microbes that make cellulase, the enzyme that hydrolyzes cellulose, so a cow can live on grass. The same water, the same glucose, and still two very different foods: what decides is whether the right catalyst is there.

MARKING SCHEME

✓ Digestion hydrolyzes the links of starch or cellulose, and the two are joined differently.
✓ Enzymes are specific: amylase fits starch's links, and we have no enzyme for cellulose's.
✓ A cow's stomach has microbes that make cellulase, so the right catalyst decides.

9 Activity: Which salts change an indicator?

(not marked)

WHAT STUDENTS SHOULD FIND

Salt changes neither: neutral. Washing soda turns red litmus blue strongly and baking soda weakly: basic. Alum and ammonium chloride turn blue litmus red: acidic. (Turmeric shows only the bases: yellow in salt and alum, red-brown in washing soda, at most faint orange in baking soda.) Salts of a strong acid and a weak base are acidic; of a weak acid and a strong base, basic.

See it at Science Playground

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- **3D Printer** (exhibit): The printer melts a plastic filament, a polymer of long chains, which hardens as it cools: a thermoplastic softens again whenever it is heated.

Marks by level	Knowledge	Understanding	Application	Higher ability	Total
Marks	11	11	17	6	**45**

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