Unit 9 · Chemistry of Non-Metals

ANSWER KEY · FOR TEACHERS

Full marks 33

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. nascent hydrogen → **g.** hydrogen at the moment it is set free in a reaction, more reactive than H_2 gas
2. heavy water → **d.** D_2O, used to slow down neutrons in some nuclear reactors
3. allotropes → **e.** different forms of the same element, with different physical properties
4. amphoteric oxide → **f.** an oxide that reacts with both acids and bases
5. peroxide → **b.** an oxide with an O–O link, in which oxygen's oxidation state is −1
6. Freon → **j.** a chlorofluorocarbon, such as CF_2Cl_2, that destroys ozone in the stratosphere
7. fullerene → **a.** an allotrope of carbon whose molecules are hollow cages, such as C_{60}
8. oil of vitriol → **i.** concentrated sulphuric acid

Each carries 0.5 mark. K · 4

2 Label the diagram

1. NH_4Cl and $Ca(OH)_2$, 2 : 1
2. hard-glass tube, mouth sloping down
3. gas jar, upside down
4. lime tower quicklime (CaO) dries the gas

Each carries 0.5 mark. K · 2

3 Multiple choice

i. **a.** water only — K · 1

The overall reaction is the same as burning hydrogen, $2H_2 + O_2 \rightarrow 2H_2O$: its only product is **water**.

ii. **c.** its layers are held together only by weak van der Waals forces — K · 1

Inside each layer the carbon atoms are strongly bonded in hexagons, but the layers are held to each other only by **weak van der Waals forces**, so they slide over one another.

iii. **b.** ammonia is a base and would react with the acid — U · 1

Ammonia is **basic**, so an acidic drying agent would react with it ($2NH_3 + H_2SO_4 \rightarrow (NH_4)_2SO_4$). Quicklime is itself a base, so it takes up only the water.

iv. **b.** +3 — U · 1

$(+1) + x + 2(-2) = 0$, so x = **+3**. (In nitric acid, HNO_3, it is +5.)

v. **b.** −1 and +1 — A · 1

In NaCl chlorine is **−1**; in NaOCl, $(+1) + x + (-2) = 0$, so **+1**. Chlorine (0) is both reduced and oxidized: a disproportionation. (Hot, concentrated alkali gives $NaClO_3$, with chlorine at +5.)

4 Short answers

a. MARKING SCHEME — U · 2

- ✓ It can't be seen, smelled or tasted.
- ✓ It binds to hemoglobin far more strongly than oxygen, so the blood carries less oxygen.

b. MARKING SCHEME — U · 2

- ✓ It decomposes to water and oxygen, faster in light and heat.
- ✓ Store in a dark bottle in a cool place.

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c. MARKING SCHEME A · 3

- ✓ $Cl_2 > Br_2 > I_2$.
- ✓ $Cl_2 + 2KI \rightarrow 2KCl + I_2$.
- ✓ No reaction between I_2 and KCl, with the reason.

5 Long answer

ANSWER U · 4

As an acid (dilute): it reacts with metals, bases and carbonates, e.g. $Zn + H_2SO_4(dil.) \rightarrow ZnSO_4 + H_2$.
As an oxidizing agent (hot, concentrated): $Cu + 2\,H_2SO_4(conc.) \rightarrow CuSO_4 + SO_2 + 2\,H_2O$; copper is oxidized and sulphur reduced from +6 to +4.
As a dehydrating agent (concentrated): it pulls the elements of water out of sugar, $C_{12}H_{22}O_{11} \rightarrow 12\,C + 11\,H_2O$, leaving black carbon.
Mixing the concentrated acid with water gives out a great deal of heat. Water added to the acid boils at once where it lands and spatters hot acid; acid added slowly to plenty of water spreads the heat through the water.

MARKING SCHEME

- ✓ An acid reaction, with its equation.
- ✓ An oxidizing reaction, with its equation.
- ✓ A dehydrating reaction, with its equation.
- ✓ The heat of mixing: acid into water, so the water takes up the heat safely.

6 Numerical problems

a. ANSWER A · 4

i. $NH_4Cl = 53.5$ g/mol: $10.7 \div 53.5 = 0.200$ mol, giving 0.200 mol of $NH_3 = 0.200 \times 17 =$ **3.40 g**.
ii. $0.200 \times 22.4 =$ **4.48 L**.
iii. 2 mol NH_3 give 1 mol urea: 0.100 mol $\times 60 =$ **6.00 g**.
iv. % N $= 28 \div 60 \times 100\% =$ **46.7%**. (Check: 46.7% of 6.00 g = 2.80 g, the nitrogen of 0.200 mol of NH_3.)

MARKING SCHEME

- ✓ 3.40 g of ammonia.
- ✓ 4.48 L at STP.
- ✓ 6.00 g of urea.
- ✓ 46.7% nitrogen.

b. ANSWER A · 4

i. 1 L gives 20 L of $O_2 = 20 \div 22.4 = 0.893$ mol, which needs $2 \times 0.893 = 1.786$ mol of $H_2O_2 \times 34 =$ **60.7 g** (60.7 g/L).
ii. $MnO_2 = 87$ g/mol: $8.7 \div 87 = 0.100$ mol, giving 0.100 mol of $Cl_2 =$ **2.24 L** at STP. HCl used: $4 \times 0.100 = 0.400$ mol $\times 36.5 =$ **14.6 g**.

MARKING SCHEME

- ✓ 0.893 mol of O_2, so 1.786 mol of H_2O_2.
- ✓ 60.7 g of H_2O_2 per liter.
- ✓ 2.24 L of chlorine.
- ✓ 14.6 g of HCl.

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7 Think

ANSWER HA · 3

High up, in the stratosphere, the ozone layer absorbs most of the Sun's harmful ultraviolet light (each O_3 split by UV is remade), shielding living things from skin cancer, eye damage and harm to crops. Losing it, as CFCs destroy it, lets more UV reach the ground.

Near the ground, where we breathe, ozone is a strong oxidizing agent that irritates the lungs and eyes and harms plants: there it is a pollutant.

So the same gas helps in one place and harms in the other; Anisha is right only about the air we breathe.

MARKING SCHEME

- ✓ The stratosphere's ozone absorbs harmful UV and protects life.
- ✓ Ozone near the ground is a harmful, irritating oxidizer (a pollutant).
- ✓ The same gas: useful high up, harmful where we breathe.

8 Activity: Rust takes oxygen

(not marked)

WHAT STUDENTS SHOULD FIND

The steel wool turns **rusty** and the water slowly rises inside the glass, then stops, after taking up about **one fifth** of the trapped air. The iron rusts by combining with the **oxygen** of the air (helped by water), so the oxygen is used up and water rises to take its place. Air is about 21% oxygen by volume; the rest, mostly nitrogen, is left.

Marks by level	Knowledge	Understanding	Application	Higher ability	Total
Marks	8	10	12	3	**33**

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