Unit 18 · Chemistry in the Service of Mankind

ANSWER KEY · FOR TEACHERS

Full marks 37

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

1 Key words

i. ✓ **True** — U · 3

ii. ✗ **False**: Bakelite is a thermosetting polymer: its chains are cross-linked in three dimensions, so heat can't soften it.

iii. ✗ **False**: The chromophore gives the color; an auxochrome gives none on its own, but deepens or shifts it and helps the dye bind.

iv. ✓ **True**

v. ✗ **False**: Antibiotics treat infections caused by bacteria; they do nothing against a cold.

vi. ✓ **True**

Each carries 0.5 mark.

2 Label the diagram

1. 4-hydroxyazobenzene (azo)
2. picric acid (nitro)
3. 1-nitroso-2-naphthol (nitroso)

U · 3

Each carries 1 mark.

3 Multiple choice

i. **b.** tetrafluoroethene — K · 1

Teflon is polytetrafluoroethene, made by adding together $CF_2{=}CF_2$ molecules. Chloroethene gives PVC, styrene polystyrene, ethene polythene.

ii. **c.** PET (Terylene) — U · 1

PET forms from ethane-1,2-diol and terephthalic acid joined by ester links, giving off water at each link. The others form by addition, with nothing given off.

iii. **c.** vat dye — K · 1

Indigo is reduced in an alkaline vat to a soluble form that soaks into the cotton, then oxidized in the air back to the insoluble blue.

iv. **c.** chloramphenicol — K · 1

Chloramphenicol acts on both gram-positive and gram-negative bacteria; penicillin G and vancomycin are narrow-spectrum. Paracetamol is not an antibiotic.

v. **b.** fungicide made of copper sulphate and slaked lime — K · 1

Copper sulphate and calcium hydroxide in water form a pale blue suspension of basic copper salts that kills fungi.

4 Short answers

a. MARKING SCHEME — U · 2

✓ Addition polymers form by repeated addition of unsaturated monomers, with nothing given off: polythene from ethene (or PVC from chloroethene, Teflon, polystyrene).

✓ Condensation polymers form by reactions between two functional groups, giving off a small molecule such as water at each step: nylon-6,6 from hexanedioic acid and hexane-1,6-diamine (or PET, Bakelite).

Science Playground, Katunje, Bhaktapur
Book a class visit: https://science-playground.com/booking

b. MARKING SCHEME U · 2

- ✓ An antiseptic is used on living tissue (skin, wounds), for example povidone-iodine, diluted Dettol or alcohol.
- ✓ A disinfectant is used on non-living objects (floors, toilets, instruments), for example bleach, formaldehyde or 1% phenol.

c. MARKING SCHEME U · 2

- ✓ When antibiotics are used carelessly, the few bacteria that survive multiply, and the antibiotic stops working against them.
- ✓ Take antibiotics only when a doctor prescribes them, exactly as prescribed, and never for a cold.

d. MARKING SCHEME A · 2

- ✓ $NaHCO_3 + HCl \rightarrow NaCl + H_2O + CO_2$
- ✓ $Mg(OH)_2 + 2\,HCl \rightarrow MgCl_2 + 2\,H_2O$

e. MARKING SCHEME U · 3

- ✓ Acid: anionic; wool, silk, nylon.
- ✓ Basic: cationic; acrylic (silk, wool, paper).
- ✓ Direct: long, flat, held by hydrogen bonds; cotton and rayon, no mordant.

5 Long answer

ANSWER U · 4

Pesticides are chemicals used to kill, repel or control pests: insects, weeds, fungi and rodents that harm people, animals and crops.
Insecticides (malathion, DDT, pyrethroids such as permethrin); herbicides (2,4-D, glyphosate); fungicides (Bordeaux mixture, copper sulphate); rodenticides (zinc phosphide).
Benefits: higher crop yields; protection of stored grain and fruit; control of insect-borne diseases such as malaria and dengue.
Harms: residues stay on vegetables and fruit; they wash into rivers and poison fish, and seep into groundwater; they kill useful insects such as bees; persistent ones such as DDT build up in food chains.

MARKING SCHEME

- ✓ The definition.
- ✓ The four groups, each with an example.
- ✓ Two benefits.
- ✓ Two harmful effects.

6 Numerical problems

a. ANSWER A · 4

i. Molar mass of $Mg(OH)_2 = 24 + 2 \times 17 = 58$ g/mol; $0.500 \text{ g} \div 58 = 8.62 \times 10^{-3}$ mol. Each mole takes 2 mol HCl: **0.0172 mol HCl**.
ii. Volume = 0.0172 mol ÷ 0.10 mol/L = 0.172 L = **172 mL**.
iii. $NaHCO_3 = 0.840 \text{ g} \div 84 \text{ g/mol} = 0.0100$ mol, giving 0.0100 mol CO_2 = **224 mL** at STP.
iv. $Mg(OH)_2$: 2 ÷ 58 = 0.0345 mol HCl per gram; $NaHCO_3$: 1 ÷ 84 = 0.0119 mol per gram. **Magnesium hydroxide**, about **2.9 times** as much.

MARKING SCHEME

- ✓ 0.0172 mol HCl.
- ✓ 172 mL of 0.10 M acid.
- ✓ 224 mL of CO_2.
- ✓ $Mg(OH)_2$, about 2.9 times as much.

Science Playground, Katunje, Bhaktapur
Book a class visit: https://science-playground.com/booking

b. **ANSWER** A · 4

i. $n\,HOOC(CH_2)_4COOH + n\,H_2N(CH_2)_6NH_2 \longrightarrow [-OC(CH_2)_4CO-NH(CH_2)_6NH-]_n + 2n\,H_2O$

ii. $C_{12}H_{22}N_2O_2$: $12 \times 12 + 22 \times 1 + 2 \times 14 + 2 \times 16 =$ **226 g/mol**.

iii. 1000 g ÷ 226 = 4.42 mol of repeat units, so 4.42 mol of each monomer: acid ($C_6H_{10}O_4$, 146 g/mol) **646 g**, diamine ($C_6H_{16}N_2$, 116 g/mol) **513 g**; water $2 \times 4.42 \times 18 =$ **159 g** (646 + 513 = 1000 + 159).

iv. Ethene, C_2H_4, is 28 g/mol: 56,000 ÷ 28 = **2,000 units**.

MARKING SCHEME

- ✓ The balanced equation, 2n H_2O given off.
- ✓ 226 g/mol.
- ✓ 646 g acid, 513 g diamine, 159 g water.
- ✓ 2,000 ethene units.

7 Think

ANSWER HA · 3

In a long conjugated system the electrons are spread over many atoms, so a smaller packet of energy raises them to a higher level. Small molecules such as ethene and benzene need packets so large that they absorb only ultraviolet, which we can't see, so they look colorless. As the conjugation grows longer, the light absorbed moves into the visible region. Methyl orange in alkali absorbs blue light, and we see the colors left over, orange-yellow.

MARKING SCHEME

- ✓ Electrons spread over a long conjugated system are raised by a smaller packet of energy.
- ✓ Small molecules absorb only ultraviolet, so look colorless; longer conjugation absorbs visible light.
- ✓ Methyl orange absorbs blue, and we see the rest, orange-yellow.

8 Activity: Polymers at home

(not marked)

WHAT STUDENTS SHOULD FIND

Typical answers: bucket or carry bag, polythene (ethene, addition, softens); water pipe or raincoat, PVC (chloroethene, addition, softens); rope or toothbrush, nylon-6,6 (hexanedioic acid and hexane-1,6-diamine, condensation); switch or pan handle, Bakelite (phenol and methanal, condensation, does not soften: thermosetting); non-stick coating, Teflon (tetrafluoroethene, addition, withstands heat); school uniform or bottle, PET (ethane-1,2-diol and terephthalic acid, condensation). Only Bakelite handles and Teflon coatings are meant to be near heat; the thermoplastics soften.

Marks by level	Knowledge	Understanding	Application	Higher ability	Total
Marks	4	20	10	3	**37**

Science Playground, Katunje, Bhaktapur
Book a class visit: https://science-playground.com/booking