Unit 12 · Basic Concepts of Organic Chemistry

ANSWER KEY · FOR TEACHERS

Full marks 35

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. vital force
2. tetracovalency
3. catenation
4. heteroatom
5. functional group
6. homologous series
7. cracking
8. knocking

K · 4

Each carries 0.5 mark.

2 Label the diagram

1. Open chain (aliphatic) chains, straight or branched
2. Alicyclic cyclohexane
3. Homocyclic (carbocyclic) a ring of carbon atoms only
4. Heterocyclic another atom in the ring: pyridine

K · 2

Each carries 0.5 mark.

3 Multiple choice

i. **c.** calcium carbide, CaC_2 — K · 1

Carbides, like CO, CO_2, carbonates and cyanides, behave like inorganic compounds and are studied with them. The other three are derivatives of hydrocarbons.

ii. **c.** propyl — U · 1

An alkyl group is an alkane less one H, C_nH_{2n+1}–: propane, C_3H_8, gives propyl, C_3H_7–.

iii. **b.** –CHO — U · 1

An aldehyde's C=O carbon also carries an H, written –CHO. –CO– inside a chain is a ketone; –COH looks like an alcohol and is never used.

iv. **b.** 55 — A · 1

The cetane number is the percentage by volume of cetane in the matching mixture: 55.

v. **c.** reforming straight-chain alkanes into aromatic hydrocarbons — A · 1

Aromatic compounds have very high octane numbers (toluene over 100); straight chains have low ones, the longer the lower.

4 Short answers

a. MARKING SCHEME — K · 2

- ✓ He made urea, a compound of living things, by heating ammonium cyanate, an inorganic salt, with no living thing involved.
- ✓ $NH_4CNO \xrightarrow{\text{heat}} NH_2CONH_2$

b. MARKING SCHEME — U · 2

- ✓ A zigzag of four lines (five carbons, at the corners and ends); contracted formula $CH_3CH_2CH_2CH_2CH_3$.
- ✓ All 12 hydrogens are left out (every H on carbon).

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c. MARKING SCHEME U · 2

- ✓ Any one, e.g. all have the same functional group (–OH) and similar chemical properties; one general formula, $C_nH_{2n+1}OH$.
- ✓ Any second, e.g. consecutive members differ by $–CH_2–$, 14 u (CH_3OH 32, C_2H_5OH 46); physical properties such as boiling point change gradually.

d. MARKING SCHEME U · 3

- ✓ The definition, with platinum as catalyst.
- ✓ Cyclization, $C_6H_{14} \rightarrow C_6H_{12} + H_2$.
- ✓ Aromatization, $C_6H_{12} \rightarrow C_6H_6 + 3H_2$.

5 Long answer

ANSWER U · 4

Knocking: when the fuel–air mixture is compressed too much, the unburnt part ahead of the flame gets so hot that it explodes all at once by itself, before the flame reaches it; the shock jerks the piston with a metallic sound, wastes fuel and damages the engine.
Octane number: the percentage by volume of iso-octane (2,2,4-trimethylpentane, 100) in a mixture with heptane (0) that has the same anti-knock property as the fuel.
Structure: straight-chain alkanes have low octane numbers, lower the longer the chain; branching raises it; cycloalkanes are higher than straight chains of the same size; aromatics are very high; double or triple bonds raise it.

MARKING SCHEME

- ✓ Knocking: early, uncontrolled explosion of the mixture before the flame arrives.
- ✓ The definition of octane number with its two reference compounds.
- ✓ Straight chains low; branching raises the number.
- ✓ Rings, aromatics and multiple bonds raise it.

6 Numerical problems

a. ANSWER A · 4

i. C : H = 85.7 ÷ 12 : 14.3 ÷ 1 = 7.14 : 14.3 = 1 : 2. Empirical formula **CH_2** (mass 14).
ii. n = 70 ÷ 14 = 5: molecular formula **C_5H_{10}**.
iii. A straight-chain alkene with the double bond at the end: **pent-1-ene**, $CH_2{=}CH–CH_2–CH_2–CH_3$.

MARKING SCHEME

- ✓ Mole ratio 1 : 2.
- ✓ Empirical formula CH_2.
- ✓ n = 5, C_5H_{10}.
- ✓ Pent-1-ene.

b. ANSWER A · 4

i. Iso-octane = 72 ÷ (72 + 18) × 100 = **80**.
ii. $C_{10}H_{22} \rightarrow C_8H_{18} + C_2H_4$: the other product is **ethene**.
iii. $C_7H_{16} \rightarrow C_7H_8 + 4H_2$. Heptane, M = 100: 1000 g ÷ 100 = 10 mol, giving 40 mol of H_2 = 40 × 2 = **80 g**.

MARKING SCHEME

- ✓ Octane number 80.
- ✓ $C_{10}H_{22} \rightarrow C_8H_{18} + C_2H_4$, ethene.
- ✓ $C_7H_{16} \rightarrow C_7H_8 + 4H_2$.
- ✓ 80 g of hydrogen.

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7 Think

ANSWER HA · 3

An alkane C_nH_{2n+2} has 2n + 2 hydrogens. Two alkanes sharing its n carbons would need (2a + 2) + (2b + 2) = 2n + 4 hydrogens, where a + b = n: two more than there are. So one piece is short of two hydrogens and makes up carbon's four bonds with a C=C double bond: an alkene, C_nH_{2n}. Small alkenes such as ethene and propene are wanted to make plastics, polythene and polypropylene.

MARKING SCHEME

- ✓ An alkane has 2n + 2 hydrogens; two alkanes from it would need 2n + 4.
- ✓ So one product is short of two H and has a C=C bond (an alkene).
- ✓ Small alkenes are used to make plastics (polythene, polypropylene).

8 Activity: Fuels at home and on the road

(not marked)

WHAT STUDENTS SHOULD FIND

Typical rows: LPG in the kitchen and kerosene in a lamp or stove (burners); petrol in motorbikes and cars (petrol engine: octane number); diesel in buses and trucks (diesel engine: cetane number). Diesel is mostly long straight chains, which ignite easily on compression: in a petrol engine they would explode early and knock badly.

Marks by level	Knowledge	Understanding	Application	Higher ability	Total
Marks	9	13	10	3	**35**

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