InkChemistry

ANSWER BOOK

Alkanes: fractional distillation, cracking and combustion

Alkanes and halogenoalkanes · Unit C17

AQA 3.3.2.1, 3.3.2.2, 3.3.2.3 · OCR A 4.1.2

19 questions · 58 marks

NAVY EDITION

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SECTION A · Short, 1 to 2 marks

A1 AF-Q5

B1 reducing the pressure lowers the boiling points of the long-chain hydrocarbons in the residue. **B1** so they can be vaporised and separated at a temperature below that at which they would decompose. [2]

A2 AF-Q9

B1 the other product is propene, $C_3H_6(g)$. **B1** two molecules of it are needed: $C_{14}H_{30}(g) \rightarrow C_8H_{18}(g) + 2C_3H_6(g)$, with 14 carbon and 30 hydrogen atoms on each side. [2]

A3 AF-Q20

B1 $C_7H_{16}(g) \rightarrow C_7H_8(g) + 4H_2(g)$, with 7 carbon and 16 hydrogen atoms on each side. **B1** the hydrogen can be used at the refinery, for example to remove sulfur from fuels. [2]

A4 AF-Q22

B1 the N≡N triple bond is very strong, 945 kJ mol^{-1}, and non-polar, so the activation energy is very high. **B1** only at the high temperature in the cylinder do enough collisions have energy equal to or above the activation energy. [2]

SECTION B · Standard, 3 to 5 marks

B1 AF-Q1

B1 the general formula of the alkanes is C_nH_{2n+2}. **B1** saturated means the molecule has only single bonds between carbon atoms, so no more atoms can be added to it. **B1** two alkanes sharing n carbon atoms would need 2n + 4 hydrogen atoms between them, but the alkane C_nH_{2n+2} has only 2n + 2. **B1** so at least one product must have fewer hydrogens, C_nH_{2n}, and contain a C=C double bond; allow a correct example equation that shows this. [4]

B2 AF-Q4

B1 the crude oil is heated in a furnace so that most of it vaporises, and the vapour is fed into the bottom of a column. **B1** the column has a temperature gradient, hottest at the bottom and coolest at the top. **B1** vapour rises and each hydrocarbon condenses on the tray where the temperature falls below its boiling point. **B1** fractions with similar boiling points are drawn off at different heights; short chains near the top, long chains near the bottom, and the residue leaves at the base. [4]

B3 AF-Q8

B1 thermal cracking uses 400 to 900 °C, whereas catalytic cracking runs at a lower temperature, about 450 °C; accept any single value in each range. **B1** thermal cracking uses a high pressure and no catalyst; catalytic cracking uses a slight pressure and a zeolite catalyst. **B1** thermal cracking goes through radicals, catalytic cracking through carbocations. **B1** thermal cracking gives a high proportion of alkenes, catalytic cracking mainly branched alkanes, cycloalkanes and aromatic hydrocarbons for petrol. [4]

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B4 AF-Q14 — **B1** $2CO(g) + 2NO(g) \rightarrow 2CO_2(g) + N_2(g)$; ignore state symbols. **B1** platinum, palladium or rhodium; reject 'a transition metal' alone. **B1** $CaCO_3(s) + SO_2(g) \rightarrow CaSO_3(s) + CO_2(g)$. **B1** the calcium sulfite is oxidised to calcium sulfate, sold as gypsum for plasterboard. [4]

B5 AF-Q18 — **B1** the converter removes most CO, NO_x and unburnt hydrocarbons, converting them to CO_2, N_2 and H_2O. **B1** it adds carbon dioxide, a greenhouse gas, and does not remove any. **B1** it does not work until it is hot, so pollutants pass through on short or cold journeys; it does not remove soot particles from a diesel engine. **B1** the claim is therefore not justified: the exhaust is much less toxic, but not harmless. [4]

B6 AF-Q3 — **B1** both have the formula C_5H_{12} and so the same number of electrons, but 2,2-dimethylpropane is branched and more compact, closer to spherical. **B1** its molecules cannot pack as closely and have a smaller surface area in contact with each other. **B1** so the van der Waals forces between its molecules are weaker and less energy is needed to separate them; reject any answer in which covalent bonds break. [3]

B7 AF-Q11 — **M1** $M_r(C_6H_{14}) = 86.0$, so the amount of hexane is $500 \div 86.0 = 5.814$ mol. **M1** each mole of hexane gives 6 mol of CO_2, so $6 \times 5.814 = 34.88$ mol of CO_2. **A1** mass = $34.88 \times 44.0 = 1535$ g $= 1.53 \times 10^3$ g, or 1.53 kg, to three significant figures. [3]

B8 AF-Q12 — **M1** $C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(l)$. **M1** equal volumes of gas hold equal amounts, so the volumes are in the mole ratio 1 : 5 : 3. **A1** 12.0 dm^3 of oxygen and 7.20 dm^3 of carbon dioxide, to three significant figures. [3]

B9 AF-Q13 — **B1** nitrogen and oxygen from the air drawn into the engine react; the nitrogen does not come from the fuel. **B1** the reaction needs the high temperature of the spark and the burning fuel: $N_2(g) + O_2(g) \rightarrow 2NO(g)$. **B1** NO is oxidised in air to NO_2, which causes acid rain or contributes to photochemical smog. [3]

B10 AF-Q15 — **B1** the honeycomb gives a very large surface area, so more gas is adsorbed onto the catalyst at once. **B1** a thin layer means only a small mass of an expensive metal is needed. **B1** the converter is cold at first and the reactions on the surface are too slow until it heats up. [3]

B11 AF-Q16 — **B1** sulfur dioxide is an acidic oxide and calcium oxide is a base, so they react together. **B1** $CaO(s) + SO_2(g) \rightarrow CaSO_3(s)$. **B1** sulfur bound into a solid fuel cannot easily be removed before it burns, whereas petrol and diesel are liquids that are desulfurised at the refinery. [3]

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B12 AF-Q17

B1 the Earth's surface, warmed by the Sun, emits infrared radiation. **B1** carbon dioxide molecules absorb some of this infrared, because it makes their bonds vibrate. **B1** they re-emit it in all directions, some back towards the surface, so the lower atmosphere is warmer than it would otherwise be. [3]

B13 AF-Q19

B1 straight-chain alkanes can ignite from compression alone, before the spark, causing knocking in a petrol engine. **B1** branched alkanes, cycloalkanes and arenes resist this early ignition and burn more smoothly. **B1** so the engine can run at a higher compression and the fuel is used more efficiently. [3]

B14 AF-Q21

B1 $SO_2(g) + NO_2(g) \rightarrow SO_3(g) + NO(g)$. **B1** $NO(g) + \frac{1}{2}O_2(g) \rightarrow NO_2(g)$, so the nitrogen dioxide is regenerated and is not used up. **B1** the sulfur trioxide dissolves in rain to give sulfuric acid: $SO_3(g) + H_2O(l) \rightarrow H_2SO_4(aq)$. [3]

B15 AF-Q23

M1 Mr of $C_8H_{18} = 8 \times 12.0 + 18 \times 1.0 = 114.0$, so the amount of octane is $1000 \div 114.0 = 8.77$ mol. **M1** energy released = $8.77 \text{ mol} \times 5470 \text{ kJ mol}^{-1}$, the negative sign of ΔH showing that the energy leaves the fuel. **A1** energy = 4.80×10^4 kJ = 48.0 MJ, to three significant figures, which is about 48 MJ; error carried forward from the amount of octane. [3]

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