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GCSE · Chemistry

C7aD Alkanes, Alkenes and Crude Oil: Exam Drill

AQA 8464 · Calculator allowed · about 90 minutes

Total Marks

Name: ______________________________ Date: ____ / ____ / ______

Answer ALL questions. Show all your working.

1 Alkanes are a homologous series of hydrocarbons.

(a) Give the general formula for the alkane homologous series. **(1)**

(Total for Question 1 is 1 mark)

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2 Name and formula questions.

(a) Write down the name of the alkane with the molecular formula C4H10. **(1)**

....

(b) Write down the empirical formula of ethene, C2H4. **(1)**

....

(Total for Question 2 is 2 marks)

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3 Properties of hydrocarbons depend on chain length.

(a) State one physical property that changes when hydrocarbon chain length increases in the fractionation of crude oil. **(1)**

(b) State another property that changes as chain length increases. **(1)**

(Total for Question 3 is 2 marks)

4 A sample of petrol is analysed by fractional distillation. The petrol fraction boils between 40 degrees C and 200 degrees C.

(a) Explain why molecules in the petrol fraction stay as a liquid at room temperature but separate from heavier fractions in the column. **(3)**

(Total for Question 4 is 3 marks)

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5 Combustion of hexane, C6H14, in excess oxygen gives carbon dioxide and water.

(a) Write the balanced symbol equation for the complete combustion of hexane. **(2)**

(b) Calculate the number of moles of CO2 produced when 1.00 mol of hexane undergoes complete combustion. Show substitution. **(1)**

....

(Total for Question 5 is 3 marks)

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6 Cracking converts long-chain hydrocarbons to shorter alkanes and alkenes. In a classroom catalytic cracking experiment a student passes vapour over a hot catalyst and collects products. They measure 5.00 g of a product mixture containing 2.00 g of ethene, C2H4.

(a) Calculate the mass percentage of ethene in the product mixture. Show working. **(2)**

....

(b) Suggest one advantage of catalytic cracking compared with thermal cracking for industry. **(2)**

(Total for Question 6 is 4 marks)

7 Testing for alkenes: bromine water decolourises in the presence of an alkene.

(a) State the observable change when bromine water is shaken with ethene. **(1)**

(b) Explain why bromine water decolourises in this test. **(1)**

(Total for Question 7 is 2 marks)

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8 A crude oil sample is analysed and found to contain 0.50 mol of a straight-chain alkane that has 9 carbon atoms per molecule.

(a) Write the molecular formula of this alkane. **(1)**

(b) Calculate the mass of this alkane present (relative molecular mass Ar values: C = 12.0, H = 1.0). Show substitution. **(2)**

....

(Total for Question 8 is 3 marks)

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9 Incomplete combustion can produce carbon monoxide as well as carbon dioxide.

(a) Explain why a flame supplied with insufficient oxygen can produce carbon monoxide. **(2)**

(b) State one danger to humans from inhaling carbon monoxide. **(1)**

(Total for Question 9 is 3 marks)

10 A student combusts 0.250 g of propane, C3H8, in excess oxygen. Calculate the mass of CO2 produced. Relative atomic masses: C = 12.0, H = 1.0, O = 16.0.

(a) Show the balanced equation and substitute values to calculate the mass of CO2 produced. Show working in steps and state units. **(4)**

....

(Total for Question 10 is 4 marks)

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11 Required practical style: Investigating how heating a hydrocarbon affects the completeness of combustion by measuring soot on a glass plate placed above a candle flame.

(a) Outline a simple method to compare soot deposition when burning propane and butane, stating the control variables you would keep the same. Do not list apparatus only; give key steps. **(3)**

(b) Give one practical improvement that would reduce systematic error in this investigation and explain why it helps. **(2)**

(Total for Question 11 is 5 marks)

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12 Explain the differences between alkanes and alkenes in structure, bonding and reactions. In your answer include an explanation of how these differences affect their typical properties and an example reaction that demonstrates the difference. You are advised to include relevant equations and link structure to reactivity.

(Total for Question 12 is 6 marks)

13 Higher-only question. A refinery claims that after treating 10.0 kg of heavy oil by catalytic cracking, they obtain 3.20 kg of ethene (C2H4) and 4.80 kg of octane (C8H18) among other products. Calculate the mass fraction of carbon in the ethene produced and then evaluate whether the combined mass of carbon atoms in the reported ethene and octane can account for all the carbon atoms in the 10.0 kg of heavy oil. Show working. Relative atomic masses: C = 12.0, H = 1.0. State any assumption you make.

(a) Calculate the mass fraction of carbon in ethene (express as a decimal to three significant figures). **(2)**

....

(b) Calculate the total mass of carbon contained within the 3.20 kg ethene and 4.80 kg octane produced. Show substitution and units. **(2)**

....

(Total for Question 13 is 4 marks)

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14 Hydrogenation of alkenes converts them to alkanes. Ethene reacts with hydrogen in the presence of a catalyst.

(a) Write the balanced equation for the hydrogenation of ethene to form ethane, including state symbols where appropriate. **(2)**

(b) Explain why a catalyst is used and why hydrogenation is useful industrially. **(2)**

(Total for Question 14 is 4 marks)

15 Using displayed formula or word equations, show the product(s) when 2-methylpropane undergoes complete combustion. Then state one environmental concern from the large-scale combustion of hydrocarbons.

(a) Write the balanced symbol equation for the complete combustion of 2-methylpropane (C4H10). **(2)**

(b) State one environmental concern associated with large-scale hydrocarbon combustion. **(2)**

(Total for Question 15 is 4 marks)

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16 Polymerisation of alkenes forms addition polymers. A student polymerises ethene to make poly(ethene).

(a) Describe, in words or an equation, how ethene monomers form poly(ethene). **(2)**

(b) State one problem caused by some addition polymers in the environment. **(1)**

(Total for Question 16 is 3 marks)

Mark scheme · C7aD Alkanes, Alkenes and Crude Oil: Exam Drill

Question 1

- (a) **B1** C n H 2n+2 or CnH2n+2 cao
- **(a) Answer: CnH2n+2**

Question 2

- (a) **B1** butane cao (accept isobutane or methylpropane as the same isomer name)
- **(a) Answer: Butane**
- (b) **B1** CH2 cao
- **(b) Answer: CH2**

Question 3

- (a) **B1** boiling point increases cao
- **(a) Answer: Boiling point increases**
- (b) **B1** viscosity increases or volatility decreases or flammability decreases, oe
- **(b) Answer: Viscosity increases**

Question 4

- (a) **M1** states that petrol molecules have intermediate intermolecular forces compared with lighter and heavier fractions, oe
- (a) **A1** explains that at room temperature these forces are strong enough to keep molecules liquid, but weaker than heavier fractions so petrol vaporises lower in the column, oe
- (a) **A1** links boiling point range to where fraction condenses in the column, oe
- **(a) Answer: Petrol molecules have intermediate intermolecular forces; these are strong enough for them to be liquid at room temperature but weaker than heavier fractions so they vaporise and condense lower in the column; the boiling point range means they separate from heavier fractions.**

Question 5

- (a) **M1** shows correct carbon and hydrogen balance in partial form or correct coefficients for C6H14 and H2O and CO2, oe
- (a) **A1** 2C6H14 + 19O2 -> 12CO2 + 14H2O cao
- **(a) Answer: 2C6H14 + 19O2 -> 12CO2 + 14H2O**
- (b) **B1** 6.00 mol CO2 cao (from 1 mol C6H14 -> 6 mol CO2 in balanced equation)
- **(b) Answer: 6.00 mol CO2**

Question 6

- (a) **M1** substitutes into percentage: (2.00 / 5.00) x 100
- (a) **A1** 40.0% cao
- **(a) Answer: 40.0%**
- (b) **B1** higher yield of branched alkanes or more control over products, oe
- (b) **B1** lower energy requirement or works at lower temperature so cheaper, oe
- **(b) Answer: Catalytic cracking gives more control over products and often lower energy costs because it operates at lower temperatures with a catalyst.**

Question 7

- (a) **B1** orange/brown bromine water becomes colourless cao
- **(a) Answer: Orange bromine water becomes colourless**
- (b) **B1** ethene reacts with bromine by electrophilic addition, forming a colourless dibromoalkane, removing coloured bromine, oe
- **(b) Answer: Ethene reacts with bromine by electrophilic addition to form a colourless dibromoalkane, removing the coloured bromine.**

Question 8

- (a) **B1** C_9H_{20} cao
- **(a) Answer: C_9H_{20}**
- (b) **M1** substitutes: Mr = 9 x 12.0 + 20 x 1.0 = 128
- (b) **A1** mass = 0.50 x 128 = 64.0 g cao
- **(b) Answer: 64.0 g**

Question 9

- (a) **M1** states that less oxygen is available so carbon cannot be fully oxidised to CO_2, oe
- (a) **A1** explains that carbon is partially oxidised to CO (which has lower oxygen content) instead of CO_2, oe
- **(a) Answer: With insufficient oxygen carbon cannot be fully oxidised to CO_2, so partial oxidation produces CO which contains less oxygen per carbon atom.**
- (b) **B1** carbon monoxide binds to haemoglobin, reducing oxygen transport, leading to fainting, unconsciousness or death, oe
- **(b) Answer: CO binds to haemoglobin, reducing oxygen transport and causing fainting or death.**

Question 10

- (a) **M1** balanced equation shown: $C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$ or equivalent balancing
- (a) **M1** calculates Mr of propane = 3x12.0 + 8x1.0 = 44.0 and Mr of CO_2 = 12.0 + 2x16.0 = 44.0
- (a) **M1** uses moles: moles propane = 0.250 / 44.0 and moles CO_2 = 3 x moles propane
- (a) **A1** mass CO_2 = moles CO_2 x Mr CO_2 = 0.250 / 44.0 x 3 x 44.0 = 0.750 g cao
- **(a) Answer: 0.750 g**

Question 11

- (a) **M1** states method steps: burn each gas with same apparatus and place a clean glass plate at a fixed height above the flame to collect soot, repeat or time for fixed period, oe
- (a) **M1** states at least two control variables such as same distance of plate from flame, same volume or flow rate of gas, same burning time, same air flow, oe
- (a) **A1** states how to compare results quantitatively, e.g. measure darkness by photographing and comparing greyscale or measure mass increase of plate, oe
- **(a) Answer: Burn each gas under the same conditions, place a clean glass plate at a fixed height above each flame for a fixed time, then compare soot by mass increase or greyscale of photographs. Controls: plate distance, burning time, gas flow rate and room air flow.**
- (b) **M1** suggests an improvement, e.g. use a clamp and fixed spacer to ensure exact plate distance or use a balance with higher precision to measure mass change
- (b) **A1** explains reduction of systematic error, e.g. ensures consistent plate height so soot deposition is comparable or smaller balance uncertainty reduces bias, oe
- **(b) Answer: Use a clamp with a fixed spacer so the plate height above each flame is identical; this ensures the same portion of flame is sampled and reduces systematic bias between trials.**

Question 12

- **Level 3** (5-6): Detailed explanation. Explains structural differences (alkanes single C-C bonds, alkenes contain C=C), describes bonding (sigma and pi bonds) and links to reactivity with clear examples (e.g. addition of bromine to ethene), includes how properties such as saturation, boiling point trends and reactivity differ, and gives a balanced example equation. Answer is coherent and well linked.
- **Level 2** (3-4): Some correct points. Identifies that alkenes have a C=C and are more reactive than alkanes, gives at least one consequence or example (e.g. addition reaction) and mentions at least one property difference. Explanation lacks depth or linking.
- **Level 1** (1-2): Simple statements only, e.g. alkanes saturated, alkenes unsaturated, and alkenes more reactive. Little or no explanation or examples.
- **Indicative content:**
  - Alkanes have single C-C bonds and are saturated; general formula C_nH_{2n+2}. Alkenes have a carbon-carbon double bond and are unsaturated; general formula C_nH_{2n}.
  - Bonding: C-C and C-H bonds are sigma bonds; C=C contains one sigma and one pi bond; the pi bond is electron rich and weaker so more reactive.
  - Reactivity: Alkenes undergo addition reactions at the C=C (for example ethene + Br_2 -> 1,2-dibromoethane), while alkanes mainly undergo substitution and combustion.
  - Properties: Alkenes are typically more reactive, can decolourise bromine water, and similar boiling point trends with chain length but differing chemical behaviour. Saturation affects hydrogenation reactions.
  - Example equation: $C_2H_4 + Br_2 \rightarrow C_2H_4Br_2$ or structural explanation of mechanism.

Question 13

- (a) **M1** calculates Mr ethene = 2x12.0 + 4x1.0 = 28.0 and mass of C per mole = 24.0
- (a) **A1** mass fraction = 24.0 / 28.0 = 0.857 cao
- **(a) Answer: 0.857**
- (b) **M1** calculates carbon fraction for octane: Mr C_8H_{18} = 8x12.0 + 18x1.0 = 114.0 so carbon mass fraction = 96.0 / 114.0 = 0.8421
- (b) **A1** total carbon mass = 3.20 x 0.857 + 4.80 x 0.8421 = 2.742 + 4.042 = 6.78 kg (3 s.f. 6.78 kg) cao
- **(b) Answer: 6.78 kg**

Question 14

- (a) **M1** shows ethene + H_2 -> ethane with correct stoichiometry
- (a) **A1** $C_2H_4(g) + H_2(g) \rightarrow C_2H_6(g)$ cao
- **(a) Answer: $C_2H_4(g) + H_2(g) \rightarrow C_2H_6(g)$**
- (b) **M1** states catalyst provides alternative route with lower activation energy or adsorption of reactants on surface
- (b) **A1** explains industrial usefulness such as converting unsaturated fats to saturated fats or producing alkanes for fuels, oe
- **(b) Answer: A catalyst provides a lower energy pathway, often by adsorbing reactants on its surface, increasing reaction rate. Hydrogenation is useful to make saturated products like alkanes for fuels or to harden vegetable oils in food industry.**

Question 15

- (a) **M1** shows correct stoichiometry for C_4H_{10} combustion
- (a) **A1** $2C_4H_{10} + 13O_2 \rightarrow 8CO_2 + 10H_2O$ cao
- **(a) Answer: $2C_4H_{10} + 13O_2 \rightarrow 8CO_2 + 10H_2O$**
- (b) **B1** increases CO_2 in atmosphere leading to enhanced greenhouse effect and climate change, oe
- (b) **B1** or air pollution from particulates or NO_x, causing health problems, oe
- **(b) Answer: Increased CO_2 emissions leading to climate change.**

Question 16

- (a) **M1** states that C=C bonds open and monomers join in an addition reaction to form long chain
- (a) **A1** gives polymer equation such as $nC_2H_4 \rightarrow -(C_2H_4)-_n$ or description equivalent cao
- **(a) Answer: $nC_2H_4 \rightarrow -(C_2H_4)-_n$; the C=C bonds open and monomers add together to form a long chain polymer.**
- (b) **B1** non-biodegradability leading to persistent waste that pollutes land and oceans, oe