2.8 Organic Chemistry: Test Pack

AQA 8462 · Calculator allowed · about 50 minutes

Total Marks

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 Alkanes are a homologous series of hydrocarbons found in natural gas and crude oil fractions.

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

(Total for Question 1 is 1 mark)

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2 Some car exhaust emissions contain nitrogen oxides NO and NO_2, formed in engines from nitrogen and oxygen in the air. A catalytic converter reduces these nitrogen oxides back to nitrogen gas using a catalyst and carbon monoxide as a reducing agent.

(a) Write the word equation for the reaction of nitrogen monoxide with carbon monoxide to form nitrogen and carbon dioxide. **(2)**

(b) State why a catalyst is needed in a catalytic converter. **(2)**

(Total for Question 2 is 4 marks)

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3 Crude oil is an important raw material for the petrochemical industry.

(a) Define the term 'hydrocarbon'. **(1)**

(b) Describe how crude oil formed over millions of years. **(2)**

(Total for Question 3 is 3 marks)

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4 A student burns a small sample of a hydrocarbon fuel in a Bunsen burner and wants to test the gases produced to confirm which products form during complete combustion.

(a) Describe how you could test the gas produced for carbon dioxide, and state the result of a positive test. **(2)**

(b) Suggest how you could show that water is also produced by the combustion, and state what you would observe. **(2)**

(Total for Question 4 is 4 marks)

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5 Crude oil is separated into fractions using fractional distillation.

(a) Name the physical process used to separate crude oil into fractions. **(1)**

(b) Explain how fractional distillation separates crude oil into fractions, referring to the fractionating column. **(3)**

(Total for Question 5 is 4 marks)

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6 Explain briefly why straight-chain alkanes tend to have higher boiling points than branched isomers of the same molecular formula.

(a) Give the explanation. **(2)**

(Total for Question 6 is 2 marks)

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7 Propane (C_3H_8) undergoes complete combustion in a plentiful supply of oxygen. Write the balanced symbol equation for this reaction.

(Total for Question 7 is 3 marks)

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8 Ethene molecules can join together to form a polymer.

(a) Name the polymer formed when many ethene molecules join together. **(1)**

(b) Describe, with the aid of an equation, how ethene monomers join together to form this polymer. **(3)**

(c) State the type of polymerisation reaction that forms poly(ethene) from ethene. **(1)**

(Total for Question 8 is 5 marks)

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9 Long-chain hydrocarbon fractions from crude oil are less useful, and in lower demand, than shorter-chain fractions, so they are processed further by cracking.

(a) Define the term 'cracking'. **(1)**

(b) State the conditions used in (i) catalytic cracking and (ii) steam cracking. **(2)**

(c) Decane ($C_{10}H_{22}$) is cracked to produce ethene (C_2H_4) and one other product. Complete the equation and name the other product: $C_{10}H_{22}$ -> C_2H_4 + ____ **(2)**

(d) Explain why cracking is an important process for oil companies. **(2)**

(Total for Question 9 is 7 marks)

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10 Butane (C_4H_{10}) has two structural (chain) isomers: butane and 2-methylpropane.

(a) Draw the displayed formula for 2-methylpropane. **(2)**

(b) Explain what is meant by the term 'structural isomers', using butane and 2-methylpropane as your example. **(2)**

(Total for Question 10 is 4 marks)

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Mark scheme · 2.8 Organic Chemistry: Test Pack

Question 1

(a) general formula C_nH_{2n+2} cao **B1**

(a) Answer: C_nH_{2n+2}

Question 2

(a) correct reactants and products named: nitrogen monoxide + carbon monoxide -> nitrogen + carbon dioxide **M1**

(a) equation presented correctly using -> or gives cao **A1**

(a) Answer: Nitrogen monoxide + carbon monoxide -> nitrogen + carbon dioxide

(b) catalyst speeds up the reaction without being used up, allowing reactions to occur at lower temperatures or faster rates **B1**

(b) specifically allows harmful gases to be converted to less harmful ones quickly as exhaust passes through, oe **B1**

(b) Answer: A catalyst speeds up the reaction without being used up, allowing the harmful gases to be converted to less harmful ones quickly as exhaust passes through the converter.

Question 3

(a) a compound made of hydrogen and carbon atoms only **B1**

(a) Answer: A compound containing only hydrogen and carbon atoms.

(b) formed from the remains of plankton/ancient marine organisms that died and sank to the seabed (oe) **B1**

(b) buried under layers of mud/sediment and subjected to high temperature and pressure over millions of years (oe) **B1**

(b) Answer: Crude oil formed from the remains of ancient plankton/marine organisms that were buried under sediment and transformed by heat and pressure over millions of years.

Question 4

(a) states the method: bubble/pass the gas produced through limewater **M1**

(a) states the positive result: the limewater turns cloudy (milky) if carbon dioxide is present, oe **A1**

(a) Answer: Bubble the gas through limewater; the limewater turns cloudy (milky) if carbon dioxide is present.

(b) holds a cool, dry surface (e.g. a cool glass or metal spoon) above the flame, oe **B1**

(b) droplets of water/condensation form on the cool surface, showing water vapour is a product, oe **B1**

(b) Answer: Hold a cool, dry surface above the flame; droplets of water (condensation) form on it, showing that water is produced by the combustion.

Question 5

(a) fractional distillation **B1**

(a) Answer: Fractional distillation.

(b) crude oil is heated/vaporised and enters a fractionating column that is hotter at the bottom and cooler towards the top (oe) **M1**

(b) different hydrocarbons in the mixture have different boiling points, related to their chain length/relative molecular mass **M1**

(b) each fraction condenses and is collected at the height in the column where the temperature is at or just below its boiling point **A1**

(b) Answer: Vaporised crude oil rises up the column, which has a temperature gradient (hot at the bottom, cool at the top). Each hydrocarbon fraction condenses and is collected at the height where the column temperature matches its boiling point, so fractions with different boiling points are separated.

Question 6

(a) states straight-chain has larger surface area/contact and therefore stronger london (induced dipole) forces **M1**

(a) concludes this requires more energy to overcome so higher boiling point **A1**

(a) Answer: Straight-chain alkanes have a greater surface area and closer contact between molecules so stronger London dispersion forces; more energy is needed to overcome these forces so boiling point is higher.

Question 7

$3CO_2$ (carbons balanced) **M1**

$4H_2O$ (hydrogens balanced) **M1**

$5O_2$ added so oxygen atoms balance on both sides; final equation $C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$ cao **A1**

Answer: $C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$

Question 8

(a) poly(ethene)/polyethene **B1**

(a) Answer: Poly(ethene) (polyethene).

(b) n ethene ($CH_2=CH_2$) molecules are represented reacting together (oe) **M1**

(b) the C=C double bond in each monomer opens up and becomes a single C-C bond joining the monomers together in a long chain (oe) **M1**

(b) correct repeat unit shown in brackets with n outside, e.g. $n(CH_2=CH_2) \rightarrow -(CH_2-CH_2)n-$ **A1**

(b) Answer: n $CH_2=CH_2$ -> $-(CH_2-CH_2)n-$; the C=C double bonds open and join the monomers into a long chain.

(c) addition polymerisation **B1**

(c) Answer: Addition polymerisation.

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Question 9

(a) the thermal decomposition of long-chain (saturated) hydrocarbons into shorter, more useful hydrocarbon molecules, including alkenes **B1**

(a) Answer: Cracking is the thermal decomposition of long-chain hydrocarbons into smaller, more useful molecules.

(b) catalytic cracking: a high temperature (about 550-600 C) and a catalyst (e.g. aluminium oxide/zeolite) **B1**

(b) steam cracking: a very high temperature (about 800-900 C) mixed with steam, with no catalyst **B1**

(b) Answer: Catalytic cracking uses a catalyst at about 550-600 C; steam cracking uses very high temperatures (about 800-900 C) with steam and no catalyst.

(c) C_8H_{18} (atoms conserved: 10-2=8 carbons, 22-4=18 hydrogens) **M1**

(c) named as octane **A1**

(c) Answer: C_8H_{18} (octane).

(d) the demand for shorter-chain hydrocarbons (e.g. petrol) is greater than the supply obtained directly from fractional distillation, while demand for longer-chain fractions is lower than the supply (oe) **M1**

(d) cracking converts less useful long-chain hydrocarbons into more useful shorter-chain hydrocarbons and alkenes (e.g. for making polymers), matching supply to demand (oe) **A1**

(d) Answer: Cracking matches the supply of hydrocarbon fractions to consumer demand by converting excess long-chain, low-demand fractions into more useful short-chain fractions and alkenes.

Question 10

(a) shows a central carbon bonded to three other carbons (a branched skeleton) rather than a straight chain **M1**

(a) fully correct displayed formula: central CH bonded to three CH_3 groups, with all H atoms shown **A1**

(a) Answer: Displayed formula: a central carbon bonded to three CH_3 groups and one H, i.e. $(CH_3)_3CH$, with all bonds and H atoms shown.

(b) states that structural isomers have the same molecular formula (both C_4H_{10}), oe **M1**

(b) but a different structural arrangement of atoms/different structural formula, e.g. butane is a straight chain while 2-methylpropane is branched, oe **A1**

(b) Answer: Structural isomers have the same molecular formula (C_4H_{10}) but a different arrangement of atoms: butane is a straight chain while 2-methylpropane is branched.

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