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90932

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Level 1 Chemistry, 2016

90932 Demonstrate understanding of aspects of carbon chemistry

2.00 p.m. Monday 21 November 2016
Credits: Four

Achievement	Achievement with Merit	Achievement with Excellence
Demonstrate understanding of aspects of carbon chemistry.	Demonstrate in-depth understanding of aspects of carbon chemistry.	Demonstrate comprehensive understanding of aspects of carbon chemistry.

Check that the National Student Number (NSN) on your admission slip is the same as the number at the top of this page.

You should attempt ALL the questions in this booklet.

If you need more room for any answer, use the extra space provided at the back of this booklet and clearly number the question.

Check that this booklet has pages 2–10 in the correct order and that none of these pages is blank.

YOU MUST HAND THIS BOOKLET TO THE SUPERVISOR AT THE END OF THE EXAMINATION.

Excellence

TOTAL 23

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QUESTION ONE

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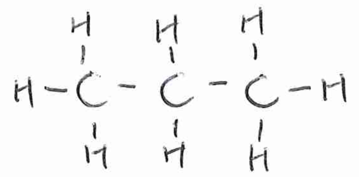
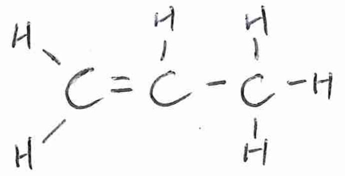
(a) Draw the structural formulae of propane and propene in the boxes below.

Propane	Propene
	

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(b) (i) What is the type of bonding present in a molecule of propane?

Single bonds, covalent bonds

Give a reason for your answer.

Propane is an alkane, which means it only contains single covalent bonds between carbon atoms, ~~and is therefore~~ so doesn't have any free bonds (each carbon atom has 4 single covalent bonds).

(ii) How does the structure of propene differ to propane?

Propane has single covalent bonds between it's carbon atoms, ~~where~~ (as it is an alkane) ~~and is~~ Propene however is an alkene, so has one double covalent bond between carbon atoms, which means it doesn't has the ~~full~~ maximum amount of hydrogen atoms possible.

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(c) Alkanes can be used as fuels. Compare and contrast: the complete combustion of alkanes, which produces carbon dioxide; and the incomplete combustion, which produces carbon monoxide and carbon in addition to carbon dioxide.

In your answer, you should:

- use butane as an example to illustrate your answer
- give an explanation of an effect on the environment for TWO combustion products
- include balanced symbol equations for the reactions occurring, in the labelled boxes below.

The complete combustion of butane occurs when there is ~~an~~ a sufficient amount of oxygen in the air for it to form the products colourless carbon dioxide gas and water. The incomplete combustion of butane however produces carbon monoxide gas, carbon (in the form of black soot) and water and occurs when there is an insufficient amount of oxygen in the air for it to form these products. Complete combustion of alkanes e.g. butane, is a ~~form~~ more efficient producer of energy than incomplete combustion. Complete combustion of butane produces carbon dioxide, which is a greenhouse gas and can have a negative impact on the environment as it contributes to the greenhouse effect. Carbon dioxide/greenhouse gases reflect infrared radiation back to Earth, raising Earth's temperature, which causes polar ice caps to melt, a rise in sea levels as well as changes in weather patterns and global warming. The incomplete combustion of butane/alkanes can also negatively impact the environment as the product; carbon particles, can scatter solar radiation, reducing plant's ability to photosynthesis efficiently and contributing to a visible haze.

Balanced symbol equation for the **complete** combustion of butane:

$C_4H_{10} + 6\tfrac{1}{2}O_2 \longrightarrow 4CO_2 + 5H_2O$

Balanced symbol equation for the **incomplete** combustion of butane:

$C_4H_{10} + 3O_2 \longrightarrow CO + \cancel{2}3C + 5H_2O$

E8

QUESTION TWO

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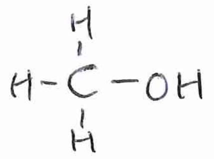
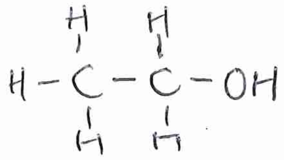
(a) Draw the structural formulae of methanol and ethanol in the boxes below.

Methanol	Ethanol
	

(b) (i) The boiling point for methanol is 65°C and ethanol is 78°C.

Why does ethanol have a higher boiling point than methanol?

Ethanol contains a higher number of carbon atoms (2 carbon atoms) compared to methanol (which has 1 carbon atom), which means it has a higher molecular mass and ~~there~~ therefore stronger intermolecular ~~attractive~~ forces between it's molecules, so more heat energy is required to break these forces in order for it to change state from a liquid to a gas, so ethanol has a higher boiling point than methanol.

(ii) Why are both methanol and ethanol soluble in water?

Methanol and ethanol are both soluble/miscible in water, as ~~when mi~~ the forces of attraction between water molecules and ethanol/methanol molecules is greater than the forces of attraction between just the methanol/ethanol molecules, so methanol and ethanol are soluble and don't form separate layers (miscible) in water.

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(c) How does the industrial preparation of methanol from natural gas differ from the process of fermentation to form ethanol?

In your answer, you should include:

- a description of the two processes
- explanations of any conditions required
- balanced symbol equations for any reactions occurring, in the labelled boxes below.

The preparation of methanol from natural gas (methane) requires 2 processes whereas fermentation is only one process. Fermentation is an enzyme controlled reaction (unlike methanol preparation) and yeast (living organisms) are used as catalysts to speed up the reaction of the breakdown of glucose into ethanol ~~into~~ and carbon dioxide. The conditions required for fermentation to occur (as yeast are living organisms so require ~~heat~~ warm conditions and moisture to live) is warm temperatures (30–40°C) so that yeast are activated and can speed up the fermentation reaction, and no oxygen present (anaerobic conditions, as when there is no oxygen, yeast break down glucose into alcohol and carbon dioxide). The preparation of methanol is different to fermentation as some of the conditions required are different. For the first process (reforming process) methane (natural gas) is reacted with steam under high temperatures (~~arouto~~ around 800°C), high pressure and a catalyst to produce hydrogen (synthesis) gas and carbon monoxide. The ratio of carbon monoxide to hydrogen is then adjusted so it's suitable for the next step. The second process (synthesis process) reacts hydrogen with carbon monoxide under lower temperatures (around 200–250°C), and with the presence of a copper or zinc catalyst to produce methanol. Fermentation and methanol preparation are different as they require different conditions, different steps and produce ~~different~~ different products.

Balanced symbol equation(s) for the industrial preparation of methanol:

$$CH_4 + H_2O \rightarrow 3H_2 + CO$$

$$2H_2 + CO \rightarrow CH_3OH$$

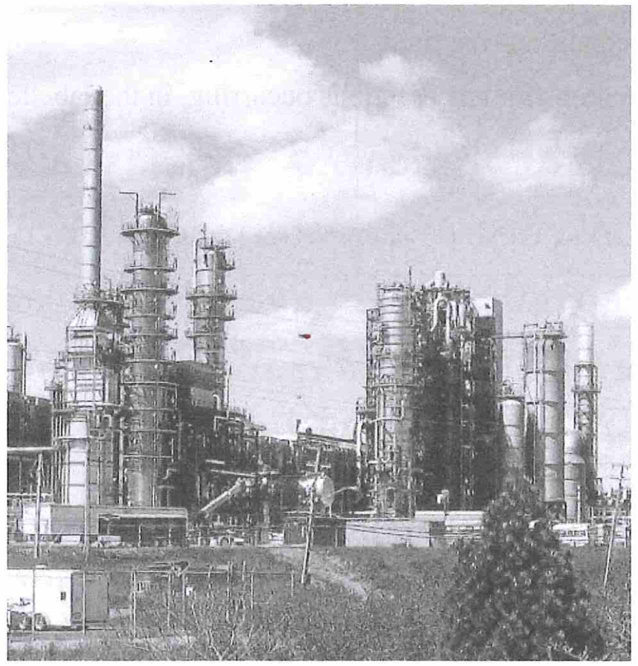
Balanced symbol equation for preparation of ethanol using fermentation:

$$C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$$

E8

QUESTION THREE

Crude oil undergoes fractional distillation in tall towers, like the ones shown in the photograph below. The different fractions produced have many uses.



http://photoartforums.com/forums/uploads/1277616145/gallery_85_17_924301.jpg

(a) Name TWO of the fractions obtained from a fractional distillation tower, and describe ONE use for each.

Fraction	Name	Use
1	Gases	For fuels e.g. methane
2	Residues	Bitumen / asphalt for roads.

(b) (i) Why does crude oil need to undergo fractional distillation before it can be used?

Crude oil is composed of many different hydrocarbons with different carbon chain lengths. Crude oil on it's own can't be used for much but once it has undergone fractional distillation, and has been separated into it's different hydrocarbons, they can be used for many things e.g. fuels.

(ii) Explain why fractional distillation is carried out in tall towers.

In your answer you should link the process of fractional distillation to the physical properties and chemical structure of the hydrocarbons in crude oil.

~~Fractional distil~~ Crude oil is first heated in a furnace to vapourise it, before it enters the fractional distillation tower. The tower has a temperature gradient inside, the top of the tower is cooler and the bottom of the tower is hotter. Different hydrocarbons have different carbon chain lengths, so different boiling points. Hydrocarbons with lots of carbon atoms have higher boiling points so stay lower down in the tower, where there is a hotter temperature, and condense and can be removed from the tower. Hydrocarbons with less carbon atoms / a smaller carbon chain length have lower boiling points so rise to the top of the tower and condense where it is cooler. ~~This~~ Hydrocarbons with 1 - 4 carbon atoms rise to the very top of the tower where they leave ~~as~~ as gases. This is because, the more ~~hydro~~carbon atoms a hydrocarbon has, the greater it's molecular mass is, so more heat energy is required to break the ~~bond betw~~ attractive forces between ~~mo~~ particles in order for them to change state, ~~Hydrocarbons with less carbon atoms have a smaller molecular mass, so less heat~~ therefore the boiling point is higher. Hydrocarbons with less carbon atoms, have a smaller molecular mass so less heat energy is required to break the attractive forces between particles in order for them to change state, therefore the boiling point is lower. Fractional distillation is carried out in tall towers, as a temperature gradient is required for the crude oil vapour to separate into it's different hydrocarbons and be removed at each fraction.

Question Three continues on the following page.

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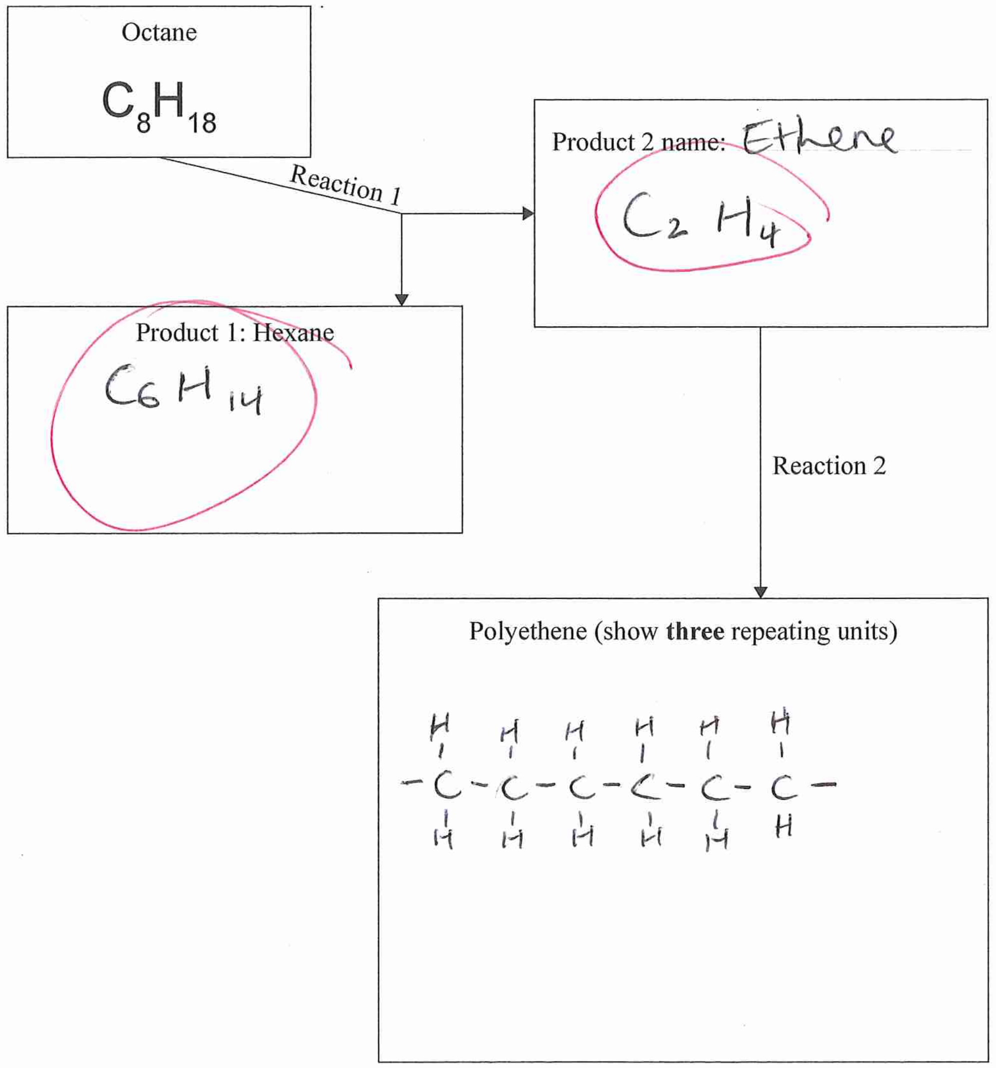
(c) Octane can be used to produce the polymer, polyethene. Octane undergoes Reaction 1 to form hexane and Product 2. Product 2 can be used to produce polyethene.

(i) Complete the reaction scheme by filling in the boxes to show all structural formulae, as well as the name for Product 2.



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(ii) Elaborate on Reaction 1 and Reaction 2.

In your answer, you should:

- name the types of reactions occurring
- give the conditions required for each reaction
- explain how polyethene can be made from Product 2.

Reaction 1 is the process of cracking, whereas Reaction 2 is the process of polymerisation. Cracking (Reaction 1) requires high pressure, high temperature and a catalyst and is done because long chain alkanes (e.g. octane) are inefficient fuels, so are cracked to produce a short chain alkane (e.g. hexane, more efficient fuel) and an ~~ethene~~ alkene (can be then used to make polymers e.g. in plastic production). Reaction 2 / Polymerisation requires the conditions of high pressure, high temperatures and a catalyst as in these conditions a polymer e.g. polyethene, can be made from monomers e.g. ethene. Ethene is ~~and~~ an alkene, which means it has ~~a~~ one double covalent bond between it's carbon atoms. During polymerisation, the double bond is broken, producing ~~2~~ single bonds and one of these single bonds covalently bonds with a neighbouring molecule (e.g. another ethene molecule) by sharing electrons in order to produce the long chain polymer; polyethene.

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E7

Excellence exemplar 2016

Subject:	Chemistry	Standard:	90932	Total score:	23

Q	Grade score	Annotation
1	E8	This question is an E8 because it has 2 balanced symbol equations, one for complete and one for incomplete combustion. It secures E8 by explaining that CO_2 is a greenhouse gas, how it increases the temperature of Earth and links this to an effect (rising sea levels / changes in weather patterns). It also explains that C particles, from incomplete combustion, scatters solar radiation leading to visible haze and a reduction of plants' ability to photosynthesise.
2	E8	The candidate has correctly balanced symbol equations for both the production of methanol from natural gas (methane) and the production of ethanol from glucose. In addition, they compare the two processes, including all the conditions required for both (in detail). They omit the naming of the Ni catalyst for methanol production, but one omission is allowed for E8.
3	E7	The candidate explains fractional distillation correctly, including the process of vaporisation of crude oil, condensation and the separation of fractions. They also clearly explain that a temperature gradient is required to separate the fractions based on boiling points, and link these to the molecular mass of the hydrocarbon chain and the temperature of the chamber. They also clearly explain the process of polymerisation including the conditions, the breaking of the C to C double bond and the forming of new single covalent bonds between adjacent monomers. The candidate needed to be more clear that the polymer chain formed from many individual monomers.