2021 ASSESSMENT MATERIALS

AS CHEMISTRY

Physical and Organic Chemistry

Total number of marks: 45

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0 4 This question is about pentan-2-ol and pent-1-ene.

0 4 . 1 The boiling point of pentan-2-ol is 119 °C
The boiling point of pent-1-ene is 30 °C

Explain why pentan-2-ol has a higher boiling point than pent-1-ene.

[3 marks]

pentan-2-ol has an OH group so hydrogen bonds form between the molecules, whereas pent-2-ene only forms van der waal's forces between the molecules which are weaker than hydrogen bonds and so require less energy to break

0 4 . 2 Pent-1-ene is formed by the elimination of water from pentan-2-ol.

State the reagent and condition for this reaction.

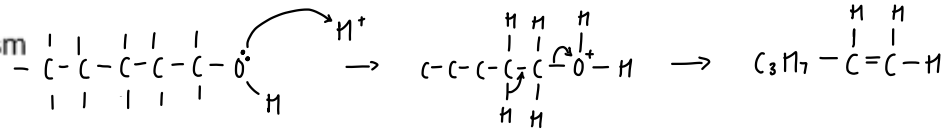
Outline the mechanism for this reaction.

[5 marks]

Reagent H_2SO_4

Condition concentrated H_2SO_4 and heat

Outline of mechanism



0 1 . 3 1-chloropropane can also be produced by the reaction between propane and chlorine in the presence of ultraviolet light.

State why ultraviolet light is needed for this reaction to occur.

Give an equation for each propagation step in the formation of 1-chloropropane from propane.

[3 marks]

Why ultraviolet light is needed uv light provides energy for the homolytic fission of chlorine to form free radicals

Propagation step 1

$CH_3CH_2CH_3 + \bullet Cl \rightarrow \bullet CH_2CH_2CH_3 + HCl$

Propagation step 2

$\bullet CH_2CH_2CH_3 + Cl_2 \rightarrow CH_2ClCH_2CH_3 + \bullet Cl$

0 1 . 4 The C–Cl bond in 1-chloropropane is polar because carbon and chlorine have different electronegativities.

Define the term electronegativity.

[1 mark]

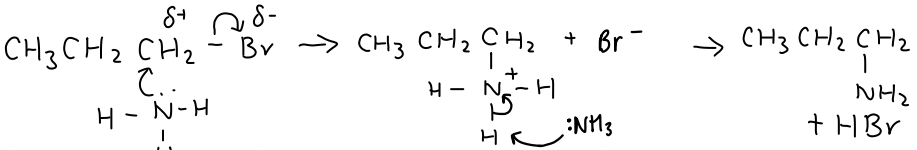
A measure of tendency of an atom to attract shared electrons to itself

0 1 . 5 Ammonia reacts with 1-chloropropane to form propylamine.

Name and outline the mechanism for this reaction.

[5 marks]

Name of mechanism nucleopilic substitution (S_N2)

Outline of mechanism 

0 8 Methanol can be manufactured in a reversible reaction as shown by the equation.

$$CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g)$$

0 8 . 1 State and explain the effect of using a catalyst on the yield of methanol in this equilibrium.

[2 marks]

Catalysts do not affect the yield of methanol as they only speeds up the rate of reaction so the equilibrium is reached faster. The equilibrium does not shift.

Catalysts speed up the rate of reaction equally on both sides.

0 8 . 2 Give an expression for the equilibrium constant (K_c) for this reaction.

[1 mark]

$$K_c = \frac{[CH_3OH]}{[CO][H_2]^2}$$

0 8 . 3 A mixture of carbon monoxide and hydrogen was allowed to reach equilibrium in a container of volume 250 cm^3 at temperature *T*.
At equilibrium, the mixture contained 0.340 mol of carbon monoxide, 0.190 mol of hydrogen and 0.0610 mol of methanol.

Calculate the value of the equilibrium constant (K_c) for this reaction at temperature *T*.
[3 marks]

$$K_c = \frac{[CH_3OH]}{[CO][H_2]^2}$$

$$K_c = \frac{\left(\frac{0.0610}{0.25}\right)}{\left(\frac{0.34}{0.25}\right)\left(\frac{0.190}{0.25}\right)^2}$$

$K_c = 0.311$

K_c 0.311 $mol^{-2}\ dm^6$

0 8 . 4 Methanol decomposes on heating in a reaction that is the reverse of that used in its manufacture.

$$CH_3OH(g) \rightleftharpoons CO(g) + 2H_2(g)$$

Use your answer from Question **08.3** to determine the value of K_c for this equilibrium at temperature *T*.
State the units for this value of K_c

(If you were unable to complete the calculation in Question **08.3**, assume a value of $K_c = 0.825\ mol^{-2}\ dm^6$. This is **not** the correct value.)
[2 marks]

$$K_{c_1} \times K_{c_2} = 1$$

$$K_{c_2} = \frac{1}{K_{c_1}}$$

$$= \frac{1}{0.311}$$

$$= 3.22$$

units : $\frac{mol\ dm^{-3} \times (mol\ dm^{-3})^2}{mol\ dm^{-3}}$

$= mol^2\ dm^{-6}$

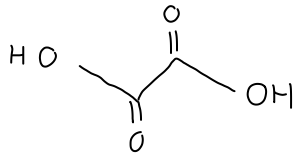
Value of K_c 3.22

Units of K_c $mol^2\ dm^{-6}$

0 7 This question is about ethanedioic acid ($H_2C_2O_4$) which is a dicarboxylic acid.

0 7 . 1 Draw the skeletal formula of ethanedioic acid.

[1 mark]



0 7 . 2 Ethanedioic acid is formed by the oxidation of ethane-1,2-diol ($HOCH_2CH_2OH$).

State suitable reagent(s) and a condition for this reaction.

[2 marks]

Reagent(s) potassium dichromate (VI) in the presence of dilute H_2SO_4

Condition heated under reflux

0 7 . 3 Ethanedioic acid reacts with an excess of sodium hydroxide to form sodium ethanedioate.

$$H_2C_2O_4(aq) + 2NaOH(aq) \rightarrow Na_2C_2O_4(aq) + 2H_2O(l)$$

A student mixes 10.0 cm^3 of 0.400 mol dm^{-3} ethanedioic acid with 50.0 cm^3 of 0.200 mol dm^{-3} sodium hydroxide.

Show that the sodium hydroxide is in excess.

Calculate the mass, in mg, of sodium ethanedioate that can be formed in this reaction.

[5 marks]

$n_{H_2C_2O_4} = \frac{10}{1000} \times 0.400$

$= 0.004$ mol

mole ratio: 1 : 2

∴ 0.008 moles of NaOH is required to react with 0.004 moles of $H_2C_2O_4$, NaOH is in excess

$n_{NaOH} = \frac{50}{1000} \times 0.200$

$= 0.01$ mol

Mass of sodium ethanedioate 536 mg

moles of $Na_2C_2O_4$ formed : 0.004 mol (by mole ratio)

mass $= 0.004 \times (23 \times 2 + 12 \times 2 + 16 \times 4)$

$= 0.004 \times 134$

$= 0.536$ g

$= 536$ mg

0 3 Compounds **A**, **B** and **C** all have the molecular formula C_5H_{10}

A and **B** decolourise bromine water but **C** does not.

B exists as two stereoisomers but **A** does **not** show stereoisomerism.

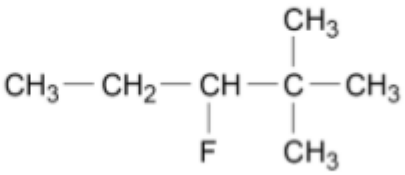
Use this information to deduce a possible structure for each of compounds **A**, **B** and **C** and explain your deductions.

State the meaning of the term stereoisomers and explain how they arise in compound **B**.

[6 marks]

(see next page)

1 1 What is the IUPAC name for this compound?



[1 mark]

A 2-dimethyl-3-fluoropentane ⬭

B 2,2-dimethyl-3-fluoropentane ⬭

C 3-fluoro-2,2-dimethylpentane ⬭

D 3-fluoro-2-dimethylpentane ⬭

1 2 What is the IUPAC name of the major product of the reaction between 2-ethylbut-1-ene and hydrogen bromide?

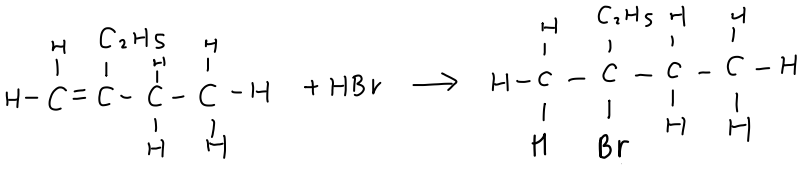
[1 mark]

A 1-bromo-2-ethylbutane ⬭

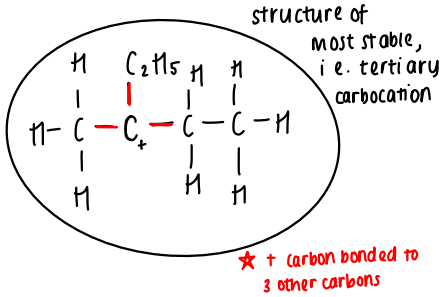
B 2-bromo-2-ethylbutane ⬬

C 2-bromo-2-methylpentane ⬭

D 3-bromo-3-methylpentane ⬭



★ major product is the one that's formed from the most stable carbocation (in this case, the 3° carbocation vs the 1° carbocation).



Question 03

A: $CH_2 = CH CH_2 CH_2 CH_3$

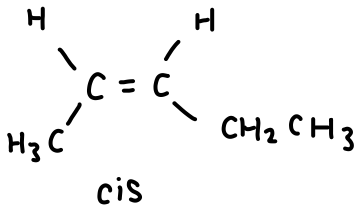
C=C double bonds allows addition of bromine water and decolourisation, 2 hydrogens are attached to carbon on one side of double bond so it cannot form cis trans isomers.

B: $CH_3 CH = CH CH_2 CH_3$

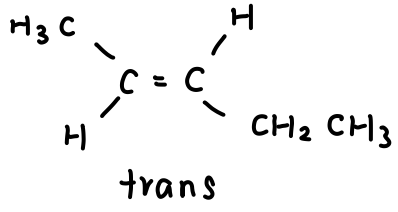
has C=C double bond which decolourises bromine water, can form stereoisomer

C:  cyclopentane has no double bonds so bromine water is not decolourised

Stereoisomers: Molecules which have the same molecular and structural formula but differs in the 3 dimensional arrangement of atoms in space



cis



trans

1 3 Which can be used to distinguish between these two compounds?

$(CH_3)_2CHCH_2CHO$ and $(CH_3)_3CCHO$

[1 mark]

A Acidified potassium dichromate(VI) ○

B Fingerprint region of infrared spectrum ●

C M_r value in high resolution mass spectrometry ○

D Tollens' reagent ○

1 9 What is the minimum volume of 0.0500 mol dm^{-3} aqueous bromine needed to react completely with 0.0200 g of buta-1,3-diene?

(M_r of buta-1,3-diene = 54.0)

[1 mark]

A 7.40 cm^3 ○

B 14.8 cm^3 ○

C 29.6 cm^3 ○

D 67.5 cm^3 ○

$$n_{\text{buta-1,3-diene}} = \frac{0.0200}{54}$$

$$= 3.7037 \times 10^{-4}$$

buta-1,3-diene contains 2 double bonds

∴ 1 mole of buta-1,3-diene reacts with 2 moles of aqueous bromine

$$n_{Br_2} = 2 \times 3.7037 \times 10^{-4}$$

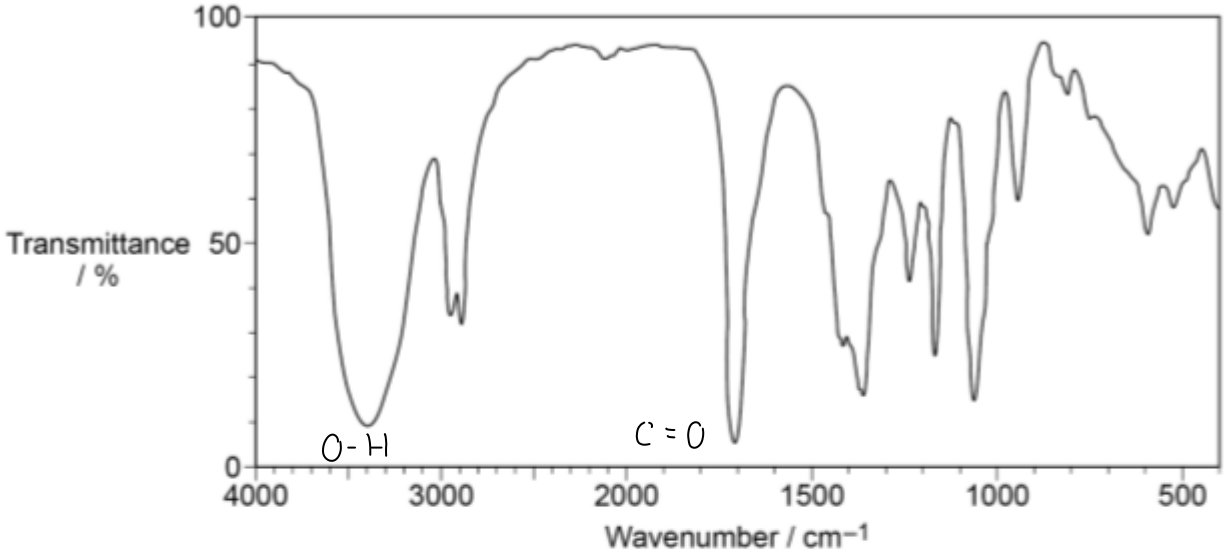
$$= 7.407 \times 10^{-4}$$

$$V = \frac{7.407 \times 10^{-4}}{0.05}$$

$$= 0.0148 \text{ dm}^3$$

$$= 14.8 \text{ cm}^3$$

2 3 The infrared spectrum of an organic compound is shown.



Which compound produces this spectrum?

[1 mark]

A ethanoic acid ⬭

B 4-hydroxybutanone ⬭

C propan-1-ol ⬭

D prop-2-en-1-ol ⬭

1 0 A 'drink-driving' offence is committed if the blood alcohol level of a driver is over 80 mg of ethanol per 100 cm^3 of blood.
What is the concentration, in mol dm^{-3}, of ethanol if there are 80 mg of ethanol (M_r = 46.0) per 100 cm^3 of blood?

[1 mark]

A 0.00017 ⬭

B 0.0017 ⬭

C 0.017 ⬭

D 1.7 ⬭

$80\,mg = 0.08\,g$

$\frac{0.08}{46} = 0.001739\ mol$

$100\,cm^3 = 0.1\ dm^3$

$\frac{0.001739\ mol}{0.1\ dm^3} = 0.01739\ mol\,dm^{-3}$