EUNOIA JUNIOR COLLEGE
JC2 Preliminary Examination 2025
General Certificate of Education Advanced Level
Higher 1

CHEMISTRY

Paper 1 Multiple Choice

8873/01

19 September 2025

1 hour

Additional Materials: Multiple Choice Answer Sheet
Data Booklet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, glue or correction fluid.
Write your name, civics group and registration number on the Answer Sheet in the spaces provided unless this has been done for you.

There are **thirty** questions on this paper. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C** and **D**.
Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

Read the instructions on the Answer Sheet very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this question paper.
The use of an approved scientific calculator is expected, where appropriate.

This document consists of **12** printed pages.

1 In which pair of atoms, in their ground states, have the same number of unpaired electrons?

A B and Ca **B** F and Na **C** Ne and P **D** Be and Si

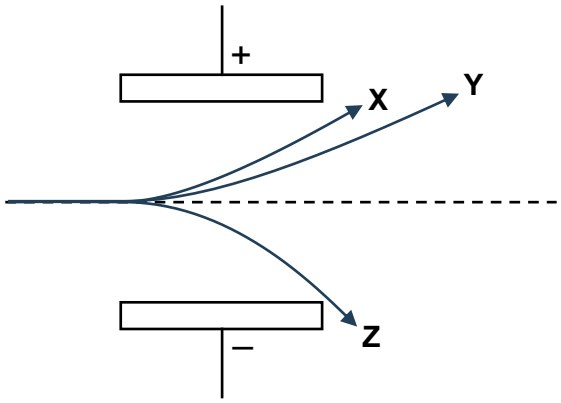
Answer: B

B: $1s^2 2s^2 2p^1$ **(1 unpaired electrons in 2p subshell)**
Ca: $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2$ **(No unpaired electrons)**

- ✓ F: $1s^2 2s^2 2p^5$ **(1 unpaired electrons in 2p subshell)**
- ✓ Na: $1s^2 2s^2 2p^6 3s^1$ **(1 unpaired electrons in 3s subshell)**

Ne: $1s^2 2s^2 2p^6$ **(No unpaired electrons)**
P: $1s^2 2s^2 2p^6 3s^2 3p^3$ **(3 unpaired electrons in 3p subshell)**
Be: $1s^2 2s^2$ **(No unpaired electrons)**
Si: $1s^2 2s^2 2p^6 3s^2 3p^2$ **(2 unpaired electrons in 3p subshell)**

2 Three particles approach an electric field at the same speed. They are deflected as they pass through the electric field.



What could be the identities of particles **X**, **Y** and **Z**?

	X	Y	Z
A	$^{35}_{17}Cl^-$	$^{37}_{17}Cl^-$	$^{23}_{11}Na^+$
B	$^{6}_{3}Li^+$	$^{7}_{3}Li^+$	$^{1}_{1}H^-$
C	$^{37}_{17}Cl^-$	$^{35}_{17}Cl^-$	$^{23}_{11}Na^+$
D	$^{7}_{3}Li^+$	$^{6}_{3}Li^+$	$^{1}_{1}H^-$

Answer: A

Since particles **X** and **Y** are deflected to the positive terminal, they are negatively charged.
Since particle **Z** is deflected to the negative terminal, it is positively charged.

Hence, **X** and **Y** must be Cl^- while **Z** must be Na^+ (either option **A** or **C** is correct).

Between particles **X** and **Y**, the larger angle of deflection of particle **X** indicates that its $\frac{e}{m}$ ratio is larger than that of **Y**. Hence, particle **X** should have a **smaller mass** number than particle **Y** since both **X** and **Y** have the same charge.

Hence, **X** is $^{35}_{17}Cl^-$ while **Y** is $^{37}_{17}Cl^-$.

3 Which molecule has the largest bond angle?

A BF_3 **B** $SiCl_4$ **C** H_2S **D** PH_3

Answer: A

A: BF_3 has a trigonal planar shape, 3 bond pairs, 0 lone pair; F–B–F angle = 120° (largest)
B: $SiCl_4$ has a tetrahedral shape, 4 bond pairs, 0 lone pair; Cl–Si–Cl angle = 109.5°
C: H_2S has a bent shape, 2 bond pairs, 2 lone pairs; H–S–H angle = 104.5°
D: PH_3 has a trigonal pyramidal shape, 3 bond pairs, 1 lone pair; H–P–H angle = 107°

4 The boiling points of hydrogen chloride, HCl, and chlorine, Cl_2 are shown in the table.

	boiling point / ºC
HCl	−85
Cl_2	−34

Which pair of statements explain this difference?

1 The forces of attraction between Cl_2 molecules are instantaneous dipole-induced dipole attractions.

2 The forces of attraction between HCl molecules are permanent dipole-permanent dipole attractions.

3 H−Cl bonds are stronger than Cl−Cl bonds.

4 The forces of attraction between Cl_2 molecules are stronger because Cl_2 molecules have more electrons.

A 1 and 2 **B** 1 and 4 **C** 2 and 3 **D** 3 and 4

Answer: B

Options 1 and 4 are correct.

Option 2 × : There are also id-id forces of attractions between HCl molecules. In addition, the pd-pd forces of attraction between HCl molecules does not explain its lower boiling point than Cl_2. In fact, the difference in their boiling points is explained using option 4.
Option 3 × : Covalent bonds are not broken when accounting for boiling points. Hence, option 3 is incorrect in explaining the difference.

5 Which of the following molecule will **not** form a hydrogen bond with another of its own molecule?

A CH_3CHO **B** CH_3NH_2 **C** CH_3OH **D** HF

Answer: A

- For hydrogen bonds to form, a hydrogen atom needs to be bonded to a very electronegative atoms (i.e., F, O or N). There must also be a lone pair of electrons on a F, O or N atom in an adjacent molecule.
- Given H atom is not bonded directly to O atom in the aldehyde, CH_3CHO (option A), hence there can be no intermolecular hydrogen bonding sformed.

6 Gases can be liquefied under certain conditions.

Which statement best describes why a gas liquefies under high pressure?

A Increasing the pressure causes the temperature of the gas to decrease to below its boiling point.

B Increasing the pressure decreases the kinetic energy of the molecules, creating the ordered liquid state.

C Increasing the pressure decreases the size of the molecules, and so the intermolecular forces of attraction become stronger.

D Increasing the pressure pushes the molecules closer together, and so the intermolecular forces of attraction become stronger.

Answer: D

A ×: Increasing the pressure does not cause the temperature to change.
B ×: K.E. of a gas is dependent on the temperature, it does not change with pressure.
C ×: The size of molecules is not affected by changes in the pressure.
D ✓: Increasing the pressure forces the molecules closer together, thereby increasing the strength of the intermolecular forces of attraction.

7 The table shows the results of experiments in which the halogens X_2, Y_2 and Z_2 were added to separate aqueous solutions containing X^-, Y^- and Z^- ions.

	X^-(aq)	Y^-(aq)	Z^-(aq)
X_2	no reaction	no reaction	no reaction
Y_2	X_2 formed	no reaction	Z_2 formed
Z_2	X_2 formed	no reaction	no reaction

Which set contains the ions X^-, Y^- and Z^- in order of their decreasing strength as a reducing agent?

	strongest ⟶ weakest		
A	X^-	Y^-	Z^-
B	X^-	Z^-	Y^-
C	Y^-	Z^-	X^-
D	Z^-	X^-	Y^-

Answer: B

The stronger the halide as a reducing agent, the more likely it will be oxidised to a halogen.

From the table, X^- is able to reduce both Y_2 and Z_2, itself oxidising to X_2. Hence, X^- is the strongest reducing agent.

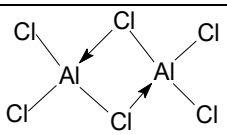
Y^- is unable to reduce any of the halogen to halides, hence Y^- is the weakest reducing agent.

8 Which element forms a chloride in which both covalent bonding and dative bonding are present?

A Mg **B** Al **C** Si **D** P

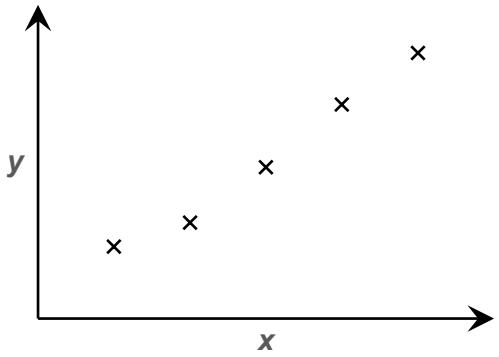
Answer: B

	Chlorides	Type of Bonding
A	$MgCl_2$	Ionic bonding with chlorine
B	$AlCl_3$ and Al_2Cl_6	Al is in group 13 and forms $AlCl_3$ via covalent bonding. It dimerises in the gaseous state to form Al_2Cl_6, consisting **covalent and dative bonds**:

		
C	$SiCl_4$	Si is in group 14 and forms 4 covalent bonds with chlorine.
D	PCl_5	P is in group 15 and forms 5 covalent bonds with chlorine.

9 *Use of the Data Booklet is relevant to this question.*

The sketch below shows the variation of properties of Period 3 elements.



Which option shows the correct label for the axes?

	y	***x***
1	melting point	nucleon number
2	electronegativity	atomic number
3	atomic radius	highest possible oxidation state

A 2 only **B** 2 and 3 **C** 1 and 3 **D** 1, 2 and 3

Answer: A

Option 1 ×: Not correct, as melting point trend increases for the first 4 elements (i.e., Na, Mg, Al and Si) across Period 3 only. Following which, the elements are simple molecules, hence have low melting points.
Option 2 ✓: Correct, as electronegativity increases the period (i.e.,increasing atomic number)
Option 3 ×: Not correct, as size of atomic radius decreases across the period.

10 Use of the *Data Booklet* is relevant to this question.

A 5 g sample of a diatomic gas, Y_2, was found to contain 3.76×10^{22} atoms.

What is the relative molecular mass of the gas?

A 40 **B** 80 **C** 120 **D** 160

Answer: D

Since Y_2 is diatomic, the no. of molecules of this gas in the 5 g sample
$= (3.76 \times 10^{22}) / 2 = 1.88 \times 10^{22}$
Hence, amount of gas $= (1.88 \times 10^{22}) / (6.02 \times 10^{23}) = 0.03125$ mol

M_r of the gas $= 5 / (0.03125) = 160$

11 Carbon disulfide vapour, $CS_2(g)$, burns in oxygen according to the following equation.

$$CS_2(g) + 4O_2(g) \rightarrow CO_2(g) + 2SO_3(g)$$

A sample of 10 cm^3 of carbon disulfide was burned in 60 cm^3 of oxygen. The residual gases were passed through sodium hydroxide.

Assuming all measurements were made at the same temperature and pressure in which CS_2 was in the gaseous state, what is the final volume of gases left?

A 50 **B** 40 **C** 30 **D** 20

Answer: D

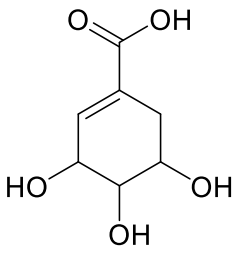
Total volume of gas before burning = 10 + 60 (of excess O_2) = 70 cm^3

Given CS_2 is the limiting reagent, based on Avogadro's Law where mol ratio is equals to volume ratio, volume of gas used = 10 (of CS_2) + 40 (of O_2) = 50 cm^3

Volume of gas produced = 10 (of CO_2) + 20 (of SO_3) = 30 cm^3
However, since CO_2 and SO_3 are both acidic gases, they would react with NaOH, hence none of the products would be left.

Hence, final volume of gas left = 70 – 50 = 20 cm^3 (of unreacted O_2)

12 Shikimic acid is a naturally occurring compound found in the spice plant star anise, also known as Japanese flower shikimi.



shikimic acid

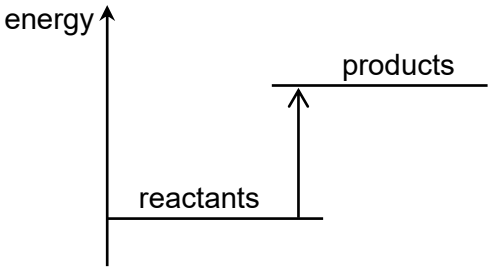
What is the percentage composition by mass of carbon in shikimic acid?

A 48.3% **B** 48.5% **C** 49.7% **D** 50.0%

Answer: A

Molecular formula is $C_7H_{10}O_5$
M_r = 7(12) + 10(1) + 5(16.0) = 174
% by mass of carbon = 7(12) / 174 x 100% = 48.3%

13 Which reaction could represent the energy level diagram shown?



A $CO_2(g) \rightarrow C(g) + 2O(g)$

B $Ca^{2+}(g) + 2Br^-(g) \rightarrow CaBr_2(s)$

C $C_2H_4(g) + 3O_2(g) \rightarrow 2CO_2(g) + 2H_2O(l)$

D $HCl(aq) + NaOH(aq) \rightarrow NaCl(aq) + H_2O(l)$

Answer: A

The energy level diagram shows an **endothermic** reaction.

A ✓: Decomposition of CO_2 into its gaseous atoms is an **endothermic** process as it involves breaking two C=O bonds in each CO_2 molecule.
B ×: Lattice energy is the energy evolved from the Formation of $CaBr_2(s)$ from its constituent gaseous ions; it is an **exothermic** process.

C ×: For a combustion reaction, its enthalpy change is **always exothermic**.
D ×: For a neutralisation reaction, its enthalpy change is **always exothermic**.

14 *Use of the Data Booklet is relevant to this question.*

Hydrazine, N_2H_4, undergoes the following reaction.

$$H_2N–NH_2(g) \xrightarrow{\boldsymbol{y}\ \text{kJ mol}^{-1}} 2N(g) + 4H(g)$$

What is the value of ***y***?

A 550 **B** 1720 **C** 1970 **D** 2550

Answer: B

ΔH = [BE (N–N) + 4 BE (N–H)] – 0
= 160 + 4(390) = 1720 kJ mol^{-1}

Use the following information to answer **Q15** and **Q16**.

Hydrogen peroxide slowly decomposes at room temperature.

$$H_2O_2(aq) \rightarrow H_2O(l) + \frac{1}{2}O_2(g)$$

A series of experiments were carried out to study the energetics and kinetics of this reaction.

15 50 cm^3 of 0.500 mol dm^{-3} aqueous hydrogen peroxide were placed in a polystyrene cup and its temperature was determined to be 23.0 ºC. 10 cm^3 of 0.500 mol dm^{-3} iron(III) nitrate, $Fe(NO_3)_3$, solution was added to catalyse the reaction.

The mixture was stirred with a thermometer and a maximum temperature of 32.2 ºC was recorded.

What is the enthalpy change of the reaction?

A −77 kJ mol^{-1} **B** −92 kJ mol^{-1} **C** −96 kJ mol^{-1} **D** −323 kJ mol^{-1}

Answer: B

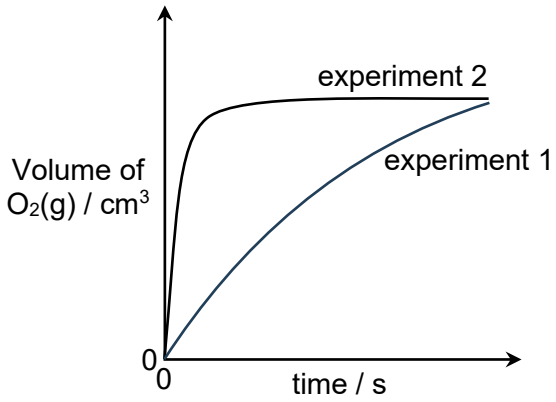
$q = –mc\Delta T$ = (50+10) x 4.18 x (32.2–23.0) = –2307.36 J
$\Delta H = q/n$
= (–2307.36/1000) / [(50/1000) x 0.500] = −92 kJ mol^{-1}

16 Two further experiments were performed to study the effects of adding lead(IV) oxide on the decomposition of hydrogen peroxide at constant temperature.

Experiment 1 : 20 cm^3 of H_2O_2
Experiment 2 : 20 cm^3 of H_2O_2 and 1.0 g of lead(IV) oxide

At the end of experiment 2, the mixture was filtered and 1.0 g of lead(IV) oxide was recovered.

The results of the experiments are as shown.



Which row is correct?

	value of rate constant	activation energy
A	equal in experiment 1 and 2	higher in experiment 1
B	equal in experiment 1 and 2	higher in experiment 2
C	higher in experiment 2	higher in experiment 1
D	higher in experiment 2	higher in experiment 2

Answer: C

From the graphs, it can be inferred that PbO_2 increases the rate of decomposition of H_2O_2, hence it is a **catalyst**.

- Catalyst increases rate by increasing the rate constant ($k_2 > k_1$), $k = Ae^{-\frac{E_a}{RT}}$.
- Catalyst provides an alternative pathway with lower E_a ($E_{a1} > E_{a2}$).

17 If the reaction **Q** + **R** → **S** + **T** is described as zero order with respect to **Q**, which of the following statements correctly describes **Q**?

A **Q** is a limiting reagent.

B The rate of reaction is independent of [**Q**].

C The concentration of **Q** does not change during the reaction.

D All of molecules **Q** do not possess energy sufficient to overcome the activation energy of the reaction.

Answer: B

A ×: There is insufficient information to deduce whether **Q** is a limiting reagent.
B ✓: A zero-order reaction is one where the change in concentration of the species does not affect the rate of reaction.
C ×: **Q** is a reactant, so it will be used up during the reaction regardless of the order of reaction, hence its concentration will decrease with time.
D ×: All molecules in a reacting mixture possess energy, but only some possess energy greater than or equals to E_a.

18 Methane, CH_4, is manufactured industrially by the catalytic reaction shown below.

$$CO_2(g) + 4H_2(g) \rightleftharpoons CH_4(g) + 2H_2O(g) \qquad \Delta H = -165 \text{ kJ mol}^{-1}$$

The operating conditions are: 350 ºC; a pressure between 25 and 35 bar; a nickel catalyst.

Which factor influences the choice of these conditions?

A The catalyst increases the equilibrium yield of methane.

B At higher pressures, the equilibrium yield of methane increases.

C At higher temperatures, the rate of formation of methane decreases.

D At higher temperatures, the equilibrium yield of methane increases.

Answer: B

A ×: Catalyst has no impact on yield. It only increases rate of forward and backward reactions to the same extent.
B ✓: At higher pressure, position of equilibrium will shift to the right to form fewer molecules of gas, hence increasing the yield of methane at equilibrium.
C ×: At high temperatures, both the rate of forward and backward reactions will increase, **not** decrease. However, the since the forward reaction is exothermic, the rate of the forward reaction increases to a smaller extent (since position of equilibrium shifts to the left to favour the backward endothermic reaction when T increases).
D ×: Position of equilibrium shifts to the left to favour the backward endothermic reaction when T increases, hence yield decreases, **not** increase.

19 The equilibrium between Fe^{3+} and I^- may be represented by

$$2Fe^{3+}(aq) + 2I^-(aq) \rightleftharpoons 2Fe^{2+}(aq) + I_2(aq)$$

In a particular mixture, the equilibrium amount of Fe^{3+} is 0.3 mol.

What will be the new equilibrium amount of Fe^{3+} if 0.5 moles of pure iron(II) sulfate is added to the mixture?

A less than 0.3 mol

B 0.3 mol

C between 0.3 mol and 0.8 mol

D 0.8 mol

Answer: C

- When Fe^{2+} is added, the position of equilibrium will shift to the left, increasing the amount of Fe^{3+}.
- Hence, the amount of Fe^{3+} will be greater than 0.3 mol.
- However, since this is a reversible reaction, it will not be a 100% conversion, hence the amount of Fe^{3+} will be less than 0.8 mol.

20 Which of the following statements regarding chemical equilibria is correct?

1 A change in pressure has no effect on the value of K_c.

2 A change in temperature will always result in a change in value of K_c.

3 For a reversible reaction at equilibrium, the rates of the forward and backward reactions are both zero.

A 1, 2 and 3 **B** 1 and 2 **C** 1 only **D** 2 only

Answer: C

Option 1 ✓: Correct, pressure does not affect the value of K_c.
Option 2 ×: Incorrect. In general, the value of K_c is affected by change in temperature. However, when $\Delta H = 0$, the value of K_c is independent of temperature change.
Option 3 ×: Incorrect. At dynamic equilibrium, rate of forward and backward reaction are the same, but not zero.

21 What is the definition of a Brønsted-Lowry acid?

A a substance that donates hydrogen ions

B a substance that accepts a lone pair of electrons

C a substance that produces hydrogen ions in aqueous solution

D a substance that readily reacts with a base to form a salt and water only

Answer : A

A: Brønsted-Lowry acid
B: Lewis acid
C: Arrhenius acid
D: A property of both Arrhenius acid and Brønsted-Lowry acid in water

22 Water dissociates into H^+ and OH^- as shown.

$$H_2O \rightleftharpoons H^+ + OH^-$$

The pH of water decreases at higher temperatures.

Which statements are correct?

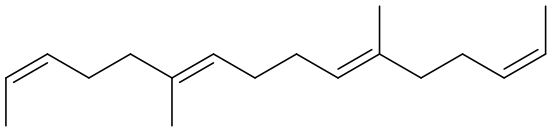
1 Water becomes acidic at higher temperatures.
2 The dissociation of water is endothermic.
3 The pOH decreases at higher temperatures.

A 1 and 2 **B** 2 and 3 **C** 1 only **D** 3 only

Answer: B

Option 1 ×:Water remains neutral, since both $[H^+]$ and $[OH^-]$ increases to the same extent at higher temperature, ensuring that $[H^+] = [OH^-]$.
Option 2 ✓: Dissociation of water is endothermic since bond breaking is involved.
Option 3 ✓: Since the dissociation of water is more favourable at higher temperatures, both $[H^+]$ and $[OH^-]$ increase at higher temperature. Hence, both pH and pOH would decrease at higher temperature.

23 How many *cis-trans* isomers does the following compound have?



A 10 **B** 16 **C** 40 **D** 64

Answer: A

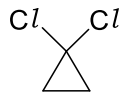
There are a total of 4 C=C double bonds that can exhibit *cis-trans*, hence we would expect a maximum of 2^4 = 16 *cis-trans* isomers.

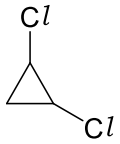
However, due to the symmetry of the molecule, there will be **fewer than** 16 isomers.
For eg, the *cis*,*cis*,*trans*,*trans* isomer will be the same as the *trans*.*trans*,*cis*,*cis* isomer.

The 10 distinct *cis-trans* isomers are
①*cis*,*cis*,*cis*,*cis* ②*cis*,*cis*,*cis*,*trans* ③*cis*,*cis*,*trans*,*cis* ④*cis*,*cis*,*trans*,*trans*
⑤*cis*,*trans*,*cis*,*trans* ⑥*trans*,*cis*,*cis*,*trans* ⑦*cis*,*trans*,*trans*,*cis* ⑧*cis*,*trans*,*trans*,*trans*
⑨*trans*,*cis*,*trans*,*trans* ⑩*trans*,*trans*,*trans*,*trans*

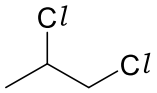
24 C_3H_6 can exist as cyclopropane or propene.

Which compound could **not** be formed by the reaction of chlorine with either hydrocarbon under suitable conditions?

A 

B 

C 

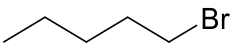
D 

Answer: C

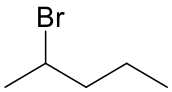
A and **B** are formed by the substitution of cyclopropane,  , by Cl_2 in the presence of uv light. There is no restriction to the C–H bonds which can be substituted.
D is formed by addition of Cl_2 across propene, $CH_3CH{=}CH_2$. The two added Cl atoms must on adjacent carbon atoms due to the C=C.
C cannot be formed by either substitution or addition of a C_3H_6 hydrocarbon.

25 Which bromoalkane gives the greatest number of different alkenes, including *cis-trans* isomers, on elimination?

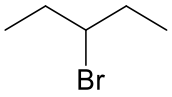
A



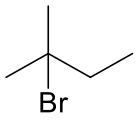
B



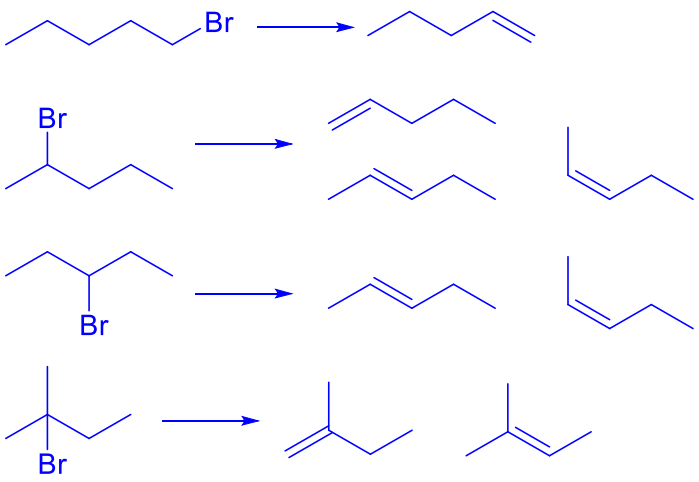
C



D



Answer: B



26 Compound **X** has the molecular formula $C_4H_{10}O_2$.

X has an unbranched carbon chain and contains two OH groups.

On reaction with an excess of hot, acidified, aqueous manganate(VII) ions, **X** is converted into a compound of molecular formula $C_4H_6O_4$.

To which two carbon atoms in the chain of **X** are the two OH groups attached?

A 1st and 2nd

B 1st and 3rd

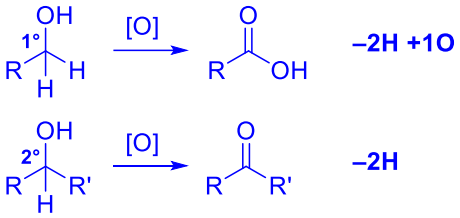
C 1st and 4th

D 2nd and 3rd

Answer: C

$C_4H_{10}O_2$ is saturated, hence is a diol, with 2 OH groups.

Oxidation with $KMnO_4$ gives $C_4H_6O_4$, with loss of 4H and gain of 2O. Hence both alcohols are 1° alcohols:



Since the X has an unbranched carbon chain, the OH groups must be on carbon 1 and 4.

27 Which ester produces butan-2-ol and ethanoic acid upon hydrolysis?

A $CH_3CO_2CH(CH_3)_2$

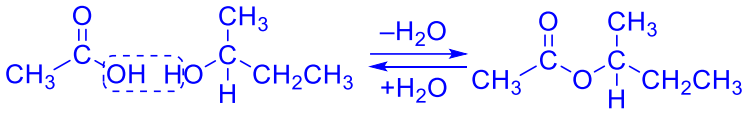
B $CH_3CO_2CH(CH_3)CH_2CH_3$

C $CH_3CH(CH_3)CO_2CH_2CH_3$

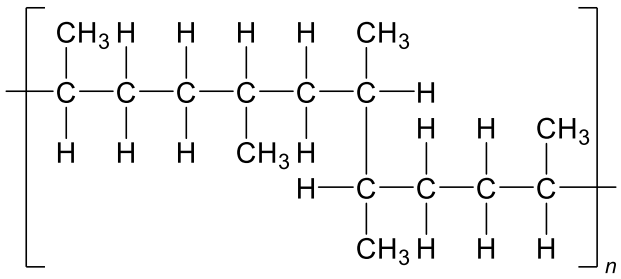
D $CH_3CH_2CO_2CH(CH_3)CH_2CH_3$

Answer: B

Butan-2-ol, $CH_3CH_2CH(OH)CH_3$, reacts with ethanoic acid, CH_3COOH, to give an ester $CH_3COOCH(CH_3)CH_2CH_3$:

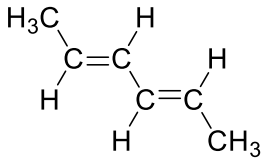


28 Which monomer will react to give the polymer shown below?



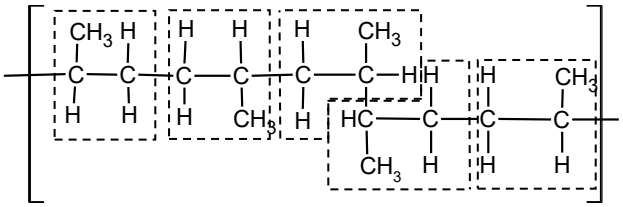
1 $CH_2{=}CH{-}CH_3$

2 $CH_3{-}CH{=}CH{-}CH_3$

3 

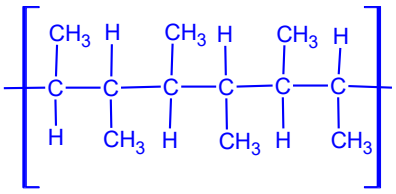
A 1 only **B** 1 and 3 **C** 1 and 2 **D** 1, 2 and 3

Answer: A

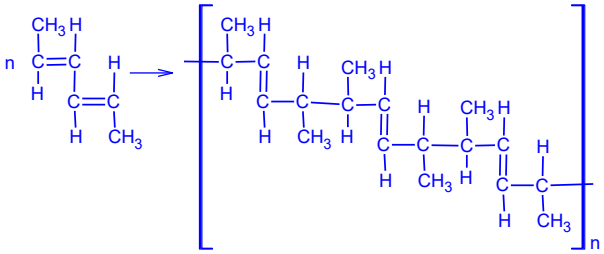


All the circled parts in the addition polymer above represent the same repeating unit. Hence, the monomer must be prop-1-ene (**option 1** is correct).

Option 2: Incorrect. But-2-tene will yield this polymer instead:



Option 3: Incorrect. This monomer will yield this polymer instead:



29 Some properties of polymers W, X, Y and Z, are shown.

polymer	properties of the polymer
W	low tensile strength and can be recycled
X	low melting point and easy to mould
Y	high tensile strength and rigid
Z	decompose when heated and cannot be recycled

Which polymers are thermosets?

A W and X **B** W and Z **C** X and Y **D** Y and Z

Answer: D

Properties of thermosets:

- ✓ Decompose/char upon heating, hence cannot be recycled
- ✓ **cross-linked** molecular structure, hence and exhibit high tensive strength and rigidity

30 Which of the following applications does not involve surface area of nanoparticles?

A Decomposition of hydrogen peroxide is faster when catalysed by manganese dioxide nanoparticles

B Removal of harmful gases in a catalytic converter

C Electrical conductivity of graphene

D Ability of gecko to climb walls

Answer: C

The electrical conductivity of graphene is **due to the sea of delocalised electrons** present as each C only uses three of its four valence electrons to form covalent bond with the neighboring C, when one non-bonding electron able to be delocalised across the layer.

The other options (**A, B** and **D**) involve 'surface area' of nanoparticles in how they work.