NATIONAL JUNIOR COLLEGE
SH 2 PRELIMINARY EXAMINATION
Higher 1

CANDIDATE NAME			
SUBJECT CLASS		REGISTRATION NUMBER	

CHEMISTRY **8873/01**
Paper 1 Multiple Choice **Wednesday 15 September 2021**
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, subject class 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 booklet.
The use of an approved scientific calculator is expected, where appropriate.
A Data Booklet is provided.

Instructions on how to fill in the Optical Mark Sheet
Shade the index number in a 5 digit format on the optical mark sheet:
1st digit and the last 4 digits of the Registration Number.

Example:

Student	Examples of Registration No.	Shade:
	2005648	25648

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

1 Which statement about 1 mol of a metal is always true?

1. It has the same number of atoms as 1 mol of hydrogen atoms.

2. It loses 1 mol of electrons.

3. It contains half the number of atoms as 2 mol of HCl(g).

4. It contains $\frac{1}{3}$ the number of ions as 3 mol of Na_2O(s).

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

1: Correct.

2: Incorrect. Different metals liberate different moles of electrons. Eg 1 mol of Mg is liberated by 2 mol of electrons. 1 mol of Na is liberated by 1 mol of electrons.

3: Incorrect. 2 mole of HCl(g) contain 4 moles of atoms.

4: Incorrect. 1 mole of Na_2O contain 3 moles of ions. For 1/3 of 3 moles of Na_2O, there are 3 moles of ions.

Answer: A

2 The actual values of the masses of three sub-atomic particles are shown in the table.

	proton	neutron	electron
mass/kg	1.673×10^{-27}	1.675×10^{-27}	9.109×10^{-31}

Which nickel ion is predicted to have a mass of 1.038×10^{-25} kg from these data?

A $^{60}_{28}Ni^{2+}$ **B** $^{62}_{28}Ni^{2+}$ **C** $^{58}_{28}Ni^{3+}$ **D** $^{64}_{28}Ni^{3+}$

	No. of protons	No. of neutrons	No. of electrons
$^{60}_{28}Ni^{2+}$	28	60 – 28 = 32	28 – 2 = 26
$^{62}_{28}Ni^{2+}$	28	62 – 28 = 34	28 – 2 = 26
$^{58}_{28}Ni^{3+}$	28	58 – 28 = 30	28 – 3 = 25
$^{64}_{28}Ni^{3+}$	28	64 – 28 = 36	28 – 3 =25

Mass = $28(1.673 \times 10^{-27}) + 34(1.675 \times 10^{-27}) + 26(9.109 \times 10^{-31})$

= 1.038×10^{-25} kg

Answer: B

3 The redox half-equations for the electrolysis of dilute sodium chloride solution are stated below.

Oxidation half-equation: $2H_2O \rightarrow O_2 + 4H^+ + 4e^-$

Reduction half-equation: $2H_2O + 2e^- \rightarrow H_2 + 2OH^-$

Which row shows the correct volume of gases if 2.40 mol of electrons are involved in the redox reaction?

	Volume of H_2 gas collected at r.t.p / dm^3	Volume of O_2 gas collected at r.t.p / dm^3
A	28.8	14.4
B	28.8	28.8
C	14.4	7.2
D	14.4	28.8

Mole ratio:

$O_2 : e^- : H_2$

1 : 4 : 2

Amount of $H_2 = \frac{2.4}{4} \times 2 = 1.2$ mol

Vol of O_2 collected $= 1.2 \times 24 = 28.8\ dm^3$

Amount of $O_2 = \frac{2.4}{4} = 0.6$ mol

Vol of O_2 collected $= 0.6 \times 24 = 14.4\ dm^3$

Answer: A

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

To identify a compound, the compound can be broken down into ions and passed through an electric field. In this electric field, the ^4He nucleus is deflected $+8^o$ and used as a standard.

An unknown ionic compound was broken down and passed through the same electric field. Two monocharged fragments were observed to have deflected $+0.6^o$ and -0.45^o.

What could be the ionic compound?

A LiC*l* **B** LiBr **C** NaC*l* **D** NaBr

angle of deflection $\alpha \frac{\text{charge size}}{\text{mass}}$

for $^4He^{2+}$, $8 = k\frac{+2}{4}$, $k = 16$

For a deflection of +0.6, $0.6 = 16 \times \frac{1}{x}$, $x = 23$

For a deflection of −0.45, $0.45 = 16 \times \frac{1}{x}$, $x = 35.5$

Compound is NaC*l*

Answer: C

5 10 cm^3 of propane, C_3H_8, was completely burnt in ***x*** cm^3 of excess oxygen. After cooling to room temperature, the volume of the residual gas was 60 cm^3. The residual gas was passed through aqueous sodium hydroxide and the volume reduced to ***y*** cm^3.

What are the values of ***x*** and ***y***?

	x	***y***
A	50	30
B	60	30
C	70	20
D	80	30

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

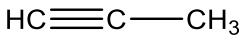
10 cm^3 requires 50 cm^3 of oxygen for complete combustion and 30 cm^3 of CO_2 will be produced.

y = volume of unreacted oxygen = 60-30 = 30 cm^3

Hence x = 50 + 30 = 80 cm^3.

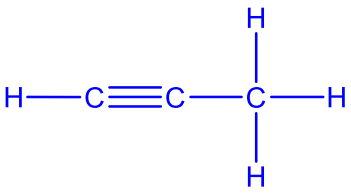
Answer: D

6 Propyne, C_3H_4, has the following structure.



Which option correctly describes the number of σ and π bonds present in a molecule of propyne?

	σ	π
A	2	2
B	2	6
C	1	3
D	6	2



All single bonds are sigma bonds. A triple bond has one sigma bond and two pi bonds. Total of 6 sigma and 2 pi bonds.

Answer: D

7 Which statement is true for **all covalent bonds**?

A A covalent bond cannot be found in ionic compounds.

B A covalent bond can be formed via head-on overlap of p orbitals.

C A covalent bond can only be formed between two non-metal atoms.

D A covalent bond is formed when each bonding atom contributes a valence electron.

A: incorrect. Polyatomic ions, such as sulfate ions (SO_4^{2-}), consists of covalent bonds between the S and O atoms.

B: correct. Fluorine is an example where the covalent bonds are formed via head-on overlap of p orbitals.

C: incorrect. Aluminium chloride is an example of a molecule with covalent bonds between metals and non-metals.

D: incorrect. A dative covalent bond is formed when the shared pair of electrons is provided by only one of the bonding atoms.

Answer: B

8 Which conditions would result in the most significant intermolecular forces between gaseous oxygen molecules?

	pressure	temperature
A	high	low
B	High	high
C	low	high
D	low	low

High pressure: oxygen molecules are closer together

Low temperature: oxygen molecules has lower kinetics energy, which will cause oxygen molecules to be closer together.

Answer: A

9 Which statements can be explained in terms of hydrogen bonding?

1 The apparent relative molecular mass of ethanoic acid in benzene is 120.

2 HF_2^- is formed when HF is dissolved in molten NaF.

3 The boiling point of propanoic acid is higher than ethanoic acid.

4 Ice is less dense than water.

A 1, 2 and 3

B 2, 3 and 4

C 1, 2 and 4

D 1 and 4

Propanoic acid has higher bp than ethanoic acid due to the larger electron cloud size of the molecule which will imply that it has stronger instantaneous dipole – induced dipole interactions.

Answer: C

10 Which species is not planar?

A BrF_3

B ICl_4^-

C PCl_4^+

D XeF_4

A: BrF_3 : T–shaped (3 bp, 2 lp)

B: ICl_4^- : square planar (4 bp, 2 lp)

C: PCl_4^+: tetrahedral (4 bp, 0 lp)

D: XeF_4: square planar (4bp, 2 lp)

Answer: C

11 Which statements are correct for all systems at dynamic equilibrium?

1 It is a closed system.

2 The rate of both forward and backward reactions is the same.

3 The concentration of reactants is equal to the concentration of products.

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

12 Nitrosyl chloride, NOC*l*, is a yellow gas that can be formed between nitryl chloride, NO_2Cl, and nitric oxide, NO, in the following reaction.

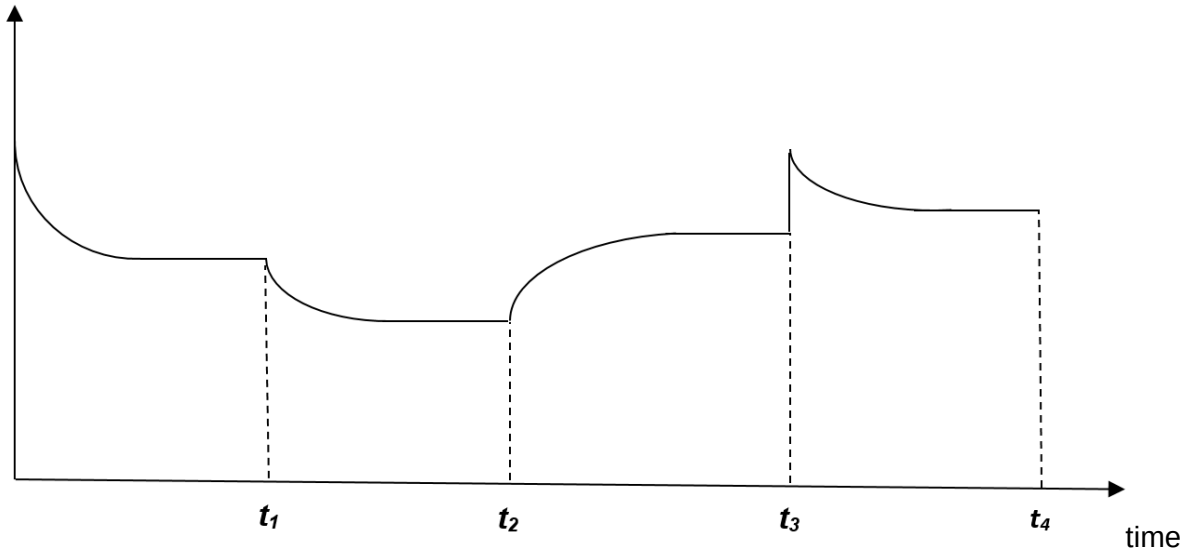
$$NO_2Cl(g) + NO(g) \rightleftharpoons NOCl(g) + NO_2(g) \qquad \Delta H < 0$$

NO_2Cl and NO were initially allowed to react in a closed vessel at 800 K and equilibrium was established.

The graph below shows how the concentration of NO_2Cl varied with time.

What could be the changes made to the system at t_1, t_2 and t_3?

concentration of NO_2Cl



	t_1	t_2	t_3
A	NO_2Cl was removed	temperature was increased	NO_2Cl was added
B	temperature was decreased	NO_2Cl was added	NO_2 was added

C	NO_2 was removed	temperature was increased	NO_2ClI was added
D	NO_2ClI was removed	NO_2ClI was added	temperature was decreased

At t_1: When NO_2 was removed, the position of equilibrium shifts right to produce more NO_2, causing the amount and hence pressure of NO_2ClI to decrease.

At t_2: When the temperature was increased, the position of equilibrium shifts left to favour the endothermic reaction by absorbing some heat. This causes the pressure of NO_2ClI to increase.

At t_3: When more NO_2ClI was added, it led to a sharp increase in pressure. The position of equilibrium then shifts right to remove some NO_2ClI, leading to a decrease in the pressure of NO_2ClI.

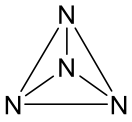
Answer: C

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

Hypothetically, N_4 could be formed from nitrogen gas by the following reaction.

$$2N_2(g) \rightarrow N_4(g) \qquad \Delta H$$

By considering the bonds broken and bonds formed, as well as the structure of N_4 given below, what would be the value of ΔH for the above reaction?



A	+140 kJ mol^{-1}	**B**	−140 kJ mol^{-1}
C	+928 kJ mol^{-1}	**D**	−928 kJ mol^{-1}

ΔH = BE(reactants)- BE(products)

= 2(+944) - 6(+160)

= +928 kJ mol^{-1}

Answer: C

14 The lattice energy of calcium chloride is numerically greater than that of potassium bromide. Which statements could explain this observation?

1 The chlorine atom is more electronegative than the bromine atom.

2 The charge on the calcium ion is greater than that of the potassium ion.

3 The Ca–C*l* bond length is shorter than that of K–Br.

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

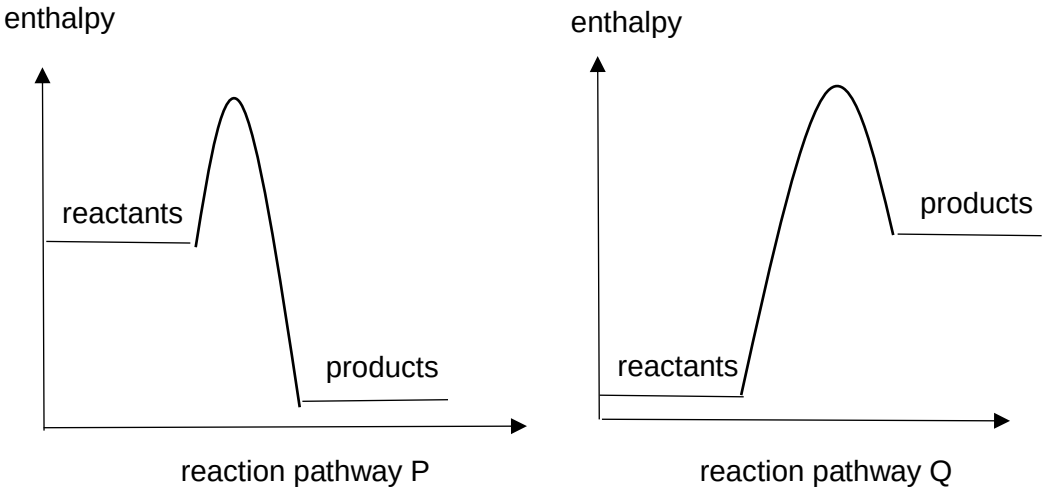
1 True statement but irrelevant to the concept of lattice energy. Moreover, lattice energy involves ions and the statement mentions atoms.

2 LE $\propto \left|\frac{q^+q^-}{r^+ + r^-}\right|$, in this case, Ca^{2+} has a greater ionic charge than K^+.

3 Ca-C*l* bond length and K-Br bond length imply covalent bonding which is irrelevant because $CaCl_2$ and KBr are ionic compounds. (Hence it is the sum of ionic radii of the ions should be taken into consideration, not "bond length".)

Answer: A

15 Reaction pathway diagrams, P and Q refer to two different types of reaction.



Which row correctly identifies the enthalpy change shown in P and Q?

	P	Q
A	lattice energy	enthalpy of formation
B	lattice energy	enthalpy of combustion
C	enthalpy of formation	enthalpy of combustion
D	enthalpy of formation	lattice energy

Lattice energy : Always exothermic

Enthalpy of formation : can be either exothermic or endothermic.

Enthalpy of combustion: always exothermic

Answer: A

16 Which statement is true about the elements in Group 1 of the Periodic Table?

A They react with water to give off oxygen gas.

B They are more readily oxidised down the group.

C Sodium is less electronegative than caesium.

B They can conduct electricity in the solid state, but not in liquid state.

1 False. They react to give off hydrogen gas.

2 True. The ease of losing electrons i.e. oxidised increase down Group 1 due to increasing weaker nuclear attraction between the most loosely held electron and the nucleus.

3 False. Electronegativity decreases down the group. Hence caesium is less electronegative than sodium.

4 False. Group 1 elements can conduct electricity in both solid and liquid state due to the presence of mobile electrons.

Answer: B

17 Which statement about the chlorides of Period 3 elements is **incorrect**?

A The pH of the solutions of chlorides generally increases across the period.

B The extent of hydrolysis of the chlorides increase across the period.

C When limited amount of water is added to the covalent chlorides, they give acidic white fumes.

D Adding NaOH(aq) to a solution of $AlCl_3$ produces a white precipitate which is soluble in an excess of NaOH.

A Incorrect. The pH of the solutions of chlorides generally decrease across the period due to increasing extent of hydrolysis of the chlorides.

B Correct.

C Correct. The white fumes is the hydrogen chloride.

D Correct. The white ppt is $Al(OH)_3$ which dissolves in excess NaOH to form soluble $Al(OH)_4^-$.

Answer: A

18 Which is an example of an Arrhenius acid and Arrhenius base reaction?

A $2CH_3COOH(aq) + Ca(OH)_2(aq) \rightarrow Ca(CH_3COO)_2(aq) + 2H_2O(l)$

B $CO_2(aq) + 2NaOH(aq) \rightarrow Na_2CO_3(aq) + H_2O(l)$

C $2HCl(aq) + Na_2O(s) \rightarrow 2NaCl(aq) + H_2O(l)$

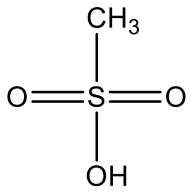
D $HCl(g) + NH_3(g) \rightarrow NH_4Cl(s)$

Arrhenius acid releases H^+ and Arrhenius base releases OH^-.

CH_3COOH releases H^+ and $Ca(OH)_2$ releases OH^-.

Answer: A

19 Methanesulfonic acid is a monobasic strong acid which is used to remove calcium carbonate from kettles.



Methanesulfonic acid

Which statement about methanesulfonic acid is **incorrect**?

A The gas evolved when methanesulfonic acid reacts with calcium carbonate is CO_2.

B 0.1 mol dm^{-3} methanesulfonic acid has a pH value of 1.

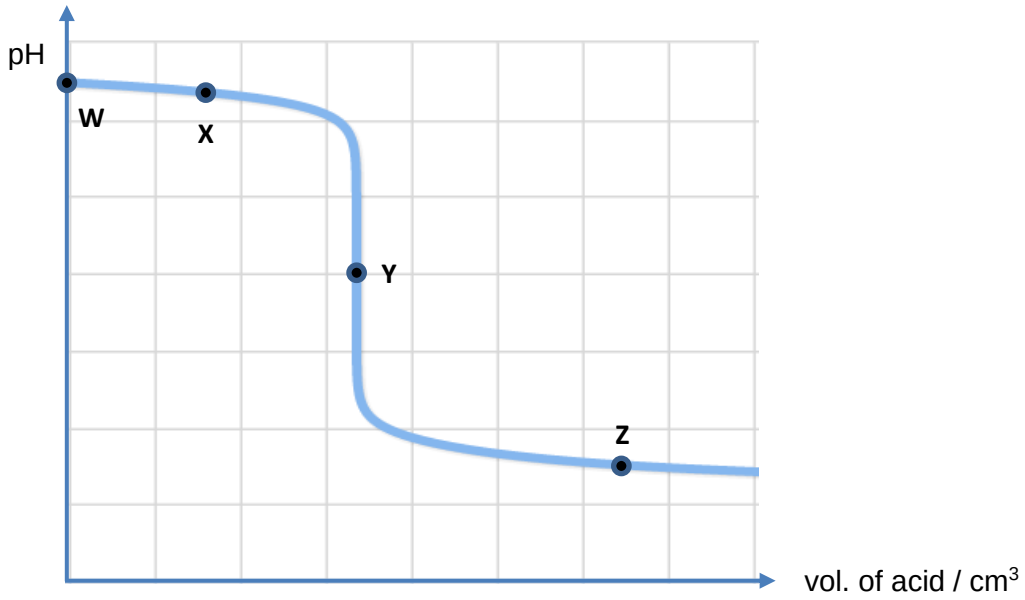
C The Brønsted-Lowry conjugate base of methanesulfonic acid is the $CH_3SO_3^-$ ion.

D The K_a value of methanesulfonic acid is very small.

A Correct. CO_2 is evolved in an acid-carbonate reaction.
B Correct. pH = –lg (0.1) = 1
C Correct. conjugate acid-base pair differ by a H^+ i.e. CH_3SO_3H / $CH_3SO_3^-$
D Incorrect. Strong acid dissociates fully. The K_a value will be a large.

Answer: D

20 The diagram shows a pH curve produced by adding a weak acid to a strong alkali.



Which point on the curve represents a solution that can act as a buffer?

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

A Point **W**: Only alkali present.
B Point **X**: Alkali (i.e. strong base) and salt
C Point **Y**: Equivalence point. Only salt present
D Point **Z**: Acidic buffer i.e. Weak acid and salt

Answer: D

21 Bromine can react with methanoic acid according to the following equation:

$$Br_2\,(aq) + HCOOH\,(aq) \rightarrow 2HBr\,(aq) + CO_2\,(g)$$

The rate of the reaction is found to be first order with respect to both bromine and methanoic acid.

Which statement is true?

A The rate constant has a unit of s^{-1}.

B The rate constant will remain unchanged with an increase in temperature.

C Halving the concentration of both reactants will halve the rate of evolution of CO_2.

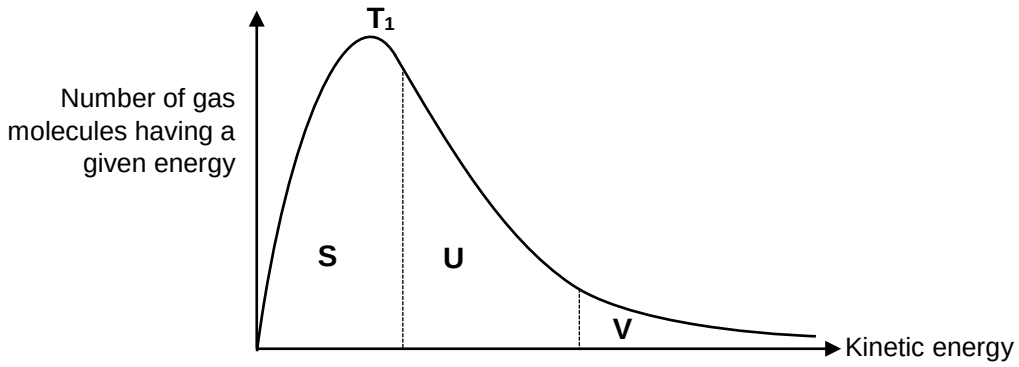
D The rate of decrease in the concentration of Br_2 is half that of the increase in the concentration of HBr.

Rate = $k[Br_2]\,[HCOOH]$

A Incorrect. unit of rate constant = $mol^{-1}\ dm^3\ s^{-1}$
B Incorrect. Rate constant is affected by temperature and E_a.
C Incorrect. Rate of reaction will be ¼ of its original value.
D Correct. Rate of formation of HBr is double of the rate of consumption of Br_2.

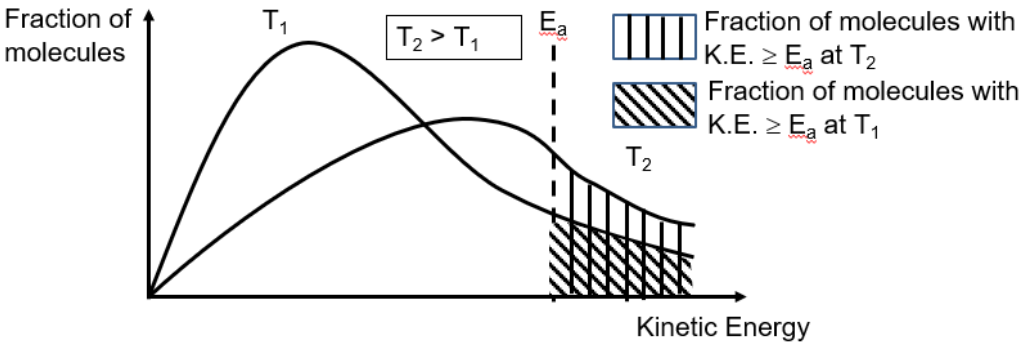
Answer: D

22 The Boltzman distribution curve shows the number of gas molecules have a particular kinetic energy at constant temperature, T_1.



What happens to the size of the areas labelled **S**, **U** and **V** when a higher temperature, T_2 was used?

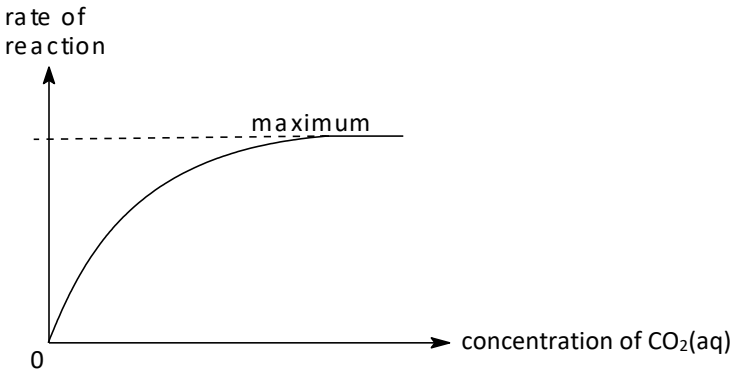
	S	U	V
A	increase	increase	decrease
B	increase	decrease	decrease
C	decrease	increase	increase
D	decrease	decrease	increase



When temperature of the reaction increases, average kinetic energy of the reacting molecules increases.
The fraction of molecules with K.E. ≥ E_a increases (shaded area under T_2 is bigger than shaded area under T_1).
The frequency of effective collisions increases hence rate of reaction increases.

Answer: C

23 The graph shows the results of an investigation on the rate of reaction of carbon dioxide with water in the presence of the enzyme carbonic anhydrase, which is found in living cells.



From the graph, which conclusion is **incorrect**?

A At low [CO_2(aq)], the reaction is first order with respect to CO_2(aq).

B At high [CO_2(aq)], the reaction is zero order with respect to CO_2(aq).

C At low [CO_2(aq)], not all of the active sites of the enzymes are occupied.

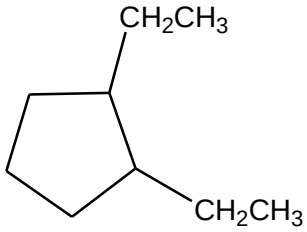
D At high [CO_2(aq)], the rate of reaction is independent of the concentration of carbonic anhydrase.

At high [CO_2(aq)], the rate of reaction is dependent of the concentration of enzyme. When more enzyme is used (i.e. more active sites available), more CO_2 will be able to bind/react with the enzymes in a highly specific manner.

Answer: D

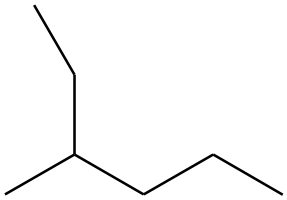
24 Which is an incorrect name of the organic species?

A



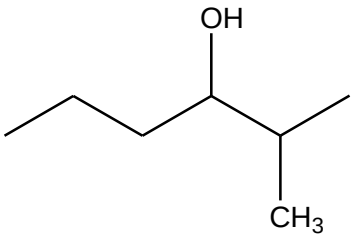
1,2-diethylcyclopentane

B



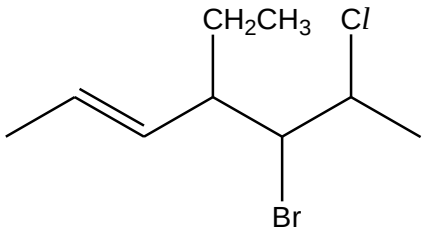
2-ethylpentane

C



2-methylhexan-3-ol

D



5-bromo-6-chloro-4-ethylhept-2-ene

There are 6 carbon atoms in the longest continuous carbon chain. Methyl substituent is on 3rd C.
Hence the name is 3-methylhexane

Answer: B

25 A straight chain organic compound has a molecular formula of C_4H_5NO. it contains a nitrile, –C≡N, functional group.

Which other functional groups could be present in this molecule?

1 aldehyde

2 alkene

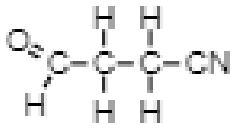
3 amide

A 1, 2 and 3 only

B 1 and 2 only

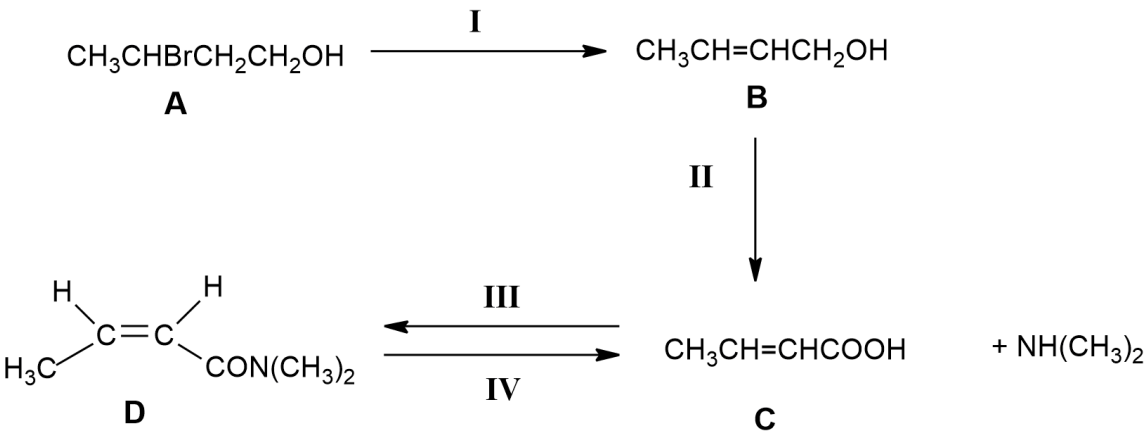
C 1 only

D 3 only



Answer: C

26 A student considered the following synthetic route to produce compound **D**.



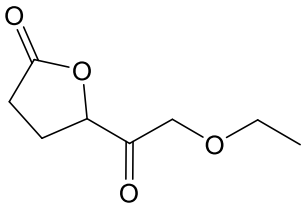
Which steps show the **correct** type of reaction and/or reagent used?

	step	type of reaction	reagent
A	**I**	elimination	concentrated H_2SO_4
B	**II**	oxidation	acidified $K_2Cr_2O_7$
C	**III**	addition	dicyclohexylcarbodiimide (DCC)
D	**IV**	substitution	aqueous KOH

Step	Type of reaction	Reagents
I	elimination	Ethanolic KOH
III	condensation	DCC
IV	acid hydrolysis	HC*l*(aq)

Answer: B

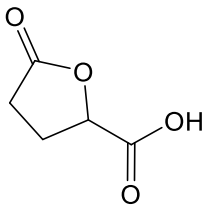
27 An ester, **T** is shown.



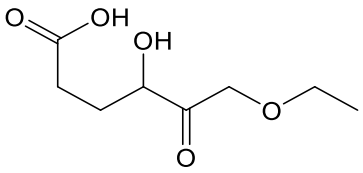
T

What is the structure of the carboxylic acid formed from the acid hydrolysis of the ester, **T**?

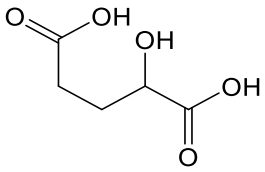
A



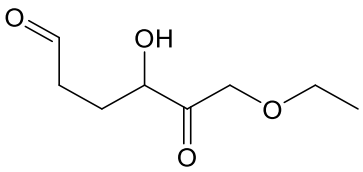
B



C

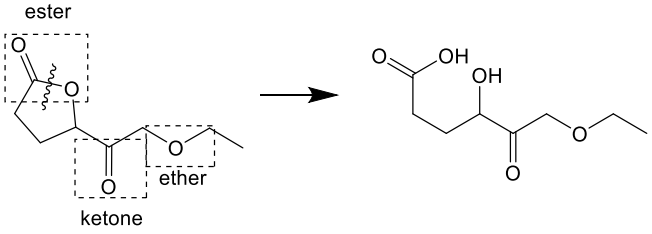


D



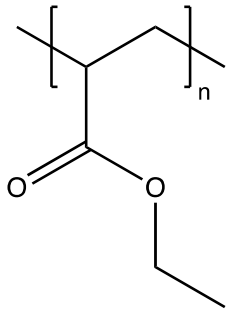
Upon acid hydrolysis, the ester group forms a carboxylic acid and an alcohol.

Note: The bottom right chain does not contain an ester group. It is a ketone and ether.



Answer: B

28 Poly(acrylate) is an addition polymer and has the following the structure.



Poly(acrylate)

What is the structure of the monomer of poly(acrylate)?

A $(OCOCH_2CH_3)CH=CH_2$

B $CH_2=CH(COCH_2CH_3)$

C $CH_2=CH(CO_2CH_3)$

D $(CO_2CH_2CH_3)CH=CH_2$

During addition polymerization, one pi bond of C=C bond is broken to form 1 sigma bond of C-C bond to join two monomers together.

Answer: D

29 Which statements correctly describe the difference between low density poly(ethane) (LDPE) and high density poly(ethane) (HDPE)?

1 The average polymer chain for HDPE is shorter than LDPE.

2 LDPE chains are branched while HDPE chains are linear.

3 LDPE has a lower flexibility than HDPE.

A 1, only

B 2 only

C 1 and 3 only

D 2 and 3 only

HDPE has a longer average polymer chain than LDPE. HDPE is more rigid and stife and hence less flexible than LDPE.

Answer: B

30 Which statements is/are correct?

1 Nanoparticles measure less than 100 nm in all three dimensions.

2 Nanoparticles unlike bulk materials have higher surface activity due to a larger surface area to volume ratio relative to bulk materials.

3 The C_{60} molecule, buckminsterfullerene, unlike graphite is not conductive at room conditions.

A 1, 2 and 3

B 1 and 2 only

C 1 only

D 2 only

1	**A**	**11**	**A**	**21**	**D**
2	**B**	**12**	**C**	**22**	**C**
3	**A**	**13**	**C**	**23**	**D**
4	**C**	**14**	**A**	**24**	**B**
5	**D**	**15**	**A**	**25**	**C**
6	**D**	**16**	**B**	**26**	**B**
7	**B**	**17**	**A**	**27**	**B**
8	**A**	**18**	**A**	**28**	**D**
9	**C**	**19**	**D**	**29**	**B**
10	**C**	**20**	**D**	**30**	**Not assessed**