SERANGOON JUNIOR COLLEGE
General Certificate of Education Advanced Level
Higher 1

CHEMISTRY 8872/01

PRELIMINARY EXAMINATION 28 August 2009
Paper 1 50 min

Additional Materials: Data Booklet
Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

Write your name, index number on the OMS Sheet in the spaces provided.

Write in soft pencil.

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

Read very carefully the instructions on the OMR answer sheet.

You are advised to fill in the OMR Answer Sheet as you go along; no additional time will be given for the transfer of answers once the examination has ended.

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.

This document consists of **14** printed pages and **0** blank page.

Answer ALL Questions

1 0.5 g of zinc powder was found to reduce an acidified solution of 25.50 cm^3 of 0.200 mol dm^{-3} VO_2^+. Which one of the following is the reduced product of VO_2^+?

A VO_3^-
B VO^{2+}
C V^{3+}
D V^{2+}

Solution: D

Amount of Zn = $\frac{0.5}{65.4} = 7.645\times10^{-3}$ mol

Amount of VO_2^+ = $\frac{25.5}{1000}\times0.200 = 5.1\times10^{-3}$ mol

$$\frac{n_{Zn}}{n_{VO_2^+}} = \frac{7.65\times10^{-3}}{5.1\times10^{-3}} = \frac{3}{2}$$

Reduction: Zinc is a reducing agent, hence it will undergo oxidation. From the *data booklet*, we choose the following half-equation:

$Zn(s) \rightarrow Zn^{2+}(aq) + 2e^-$

Given the 3 mol of Zn reacts with 2 mol of VO_2^+, we can deduce that the 2 mol of VO_2^+ takes in (2e x 3 =) 6 mol of e^- from Zn. Hence, 1 mol of VO_2^+ will take in 3 mol of e^-.
Oxidation state of V in VO_2^+ = + 5
Hence, the final oxidation state of V = +5 – 3 = +2

2 3.920 g of an oxide of formula **M**O was completely dissolved in 30.0 cm^3 of 2.00 mol dm^{-3} sulphuric acid. The resulting solution was made up to 100 cm^3. 25.0 cm^3 of this solution was neutralised by 27.5 cm^3 of 0.100 mol dm^{-3} sodium hydroxide. What is the relative molecular mass of **M**?

A 48.6
B 54.9
C 55.9
D 101.0

Solution: C

amount of NaOH = $\frac{27.5}{1000}\times0.1 = 2.75\times10^{-3}$ mol

amount of H_2SO_4 in 25.0 cm^3 of solution = ½(2.75 x 10^{-3}) = 1.375 x 10^{-3} mol

amount of H_2SO_4 in 100 cm^3 of solution = $\frac{100}{25.0} \times 1.375 \times 10^{-3} = 0.0055$ mol

amount of initial amount of H_2SO_4 = $\frac{30.0}{1000} \times 2.0 = 0.06$ mol

Therefore, the amount of H_2SO_4 that reacts with MO = 0.06 – 0.0055= 0.0545 mol
Given that 1 mol of H_2SO_4 reacts with 1 mol of **M**O (**M** has an oxidation state of +2), therefore, amount of MO in 3.518g of MO = 0.0545 mol
Given amount of MO = mass of MO/ molar mass of **M**O

0.0545 = 3.920/(molar mass of **M** + 16.0)

Molar mass of M = (3.920/0.0545) – 16.0

= 55.9 g/mol

3 One of the isotopes of carbon is carbon-14. Carbon-14 is radioactive and is used in carbon dating by archaeologists. Which one of the following species has the same number of neutrons and electrons as an atom of carbon-14?

A $^{13}C^-$
B $^{14}N^+$
C $^{16}O^{2+}$
D $^{17}F^+$

Solution:C
Number of protons in Carbon-14= 6p
Number of neutrons in Carbon-14 = 14 – 6 = 8n
Number of electrons = 6e

A	$^{13}C^-$	6p	7e	7n
B	$^{14}N^+$	7p	6e	7n
C	$^{16}O^{2+}$	8p	6e	8n
D	$^{17}F^+$	9p	8e	8n

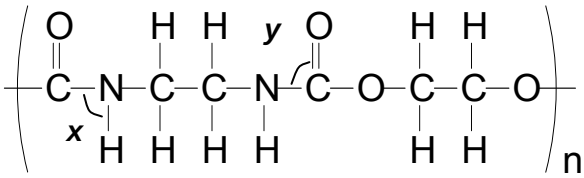
4 The electronic configurations of two atoms, **E** and **F**, are $1s^2 2s^2 2p^3$ and $1s^2 2s^2 2p^4$ respectively. Compare the first and second ionisation energies of **E** and **F**.

	1st I.E.	**2nd I.E.**
A	E < F	E > F
B	E < F	E < F
C	E > F	E > F
D	E > F	E < F

Solution: D

E: Nitrogen; F: Oxygen
1st IE of N: $N(1s^2 2s^2 2p^3) \rightarrow N^+ (1s^2 2s^2 2p^2)$
1st IE of O: $O(1s^2 2s^2 2p^4) \rightarrow O^+ (1s^2 2s^2 2p^3)$
Conclusion: The 1st IE of O is lower than the 1st IE of N as less energy is required to remove the 2p electron from the paired electrons in 2p orbital (inter-electronic repulsion). E > F.
2nd IE of N: $N^+ (1s^2 2s^2 2p^2) \rightarrow N^{2+} (1s^2 2s^2 2p^1)$
2nd IE of O: $O^+(1s^2 2s^2 2p^3) \rightarrow O^{2+} (1s^2 2s^2 2p^2)$
Conclusion: The 2nd IE of O is higher than the 2nd IE of N as both involves the removal of 2p electron from singly filled p-orbital. However, the removal of the 2p electron from O^+ will experience a greater electrostatic forces of attraction from the nucleus than that of N^+ as O^+ has greater nuclear charge (+8) than N^+ (+7). E < F

5 Polyurethane is used in coatings, insulators and adhesives.



Polyurethane

What are the values of the bond angles marked ***x*** and ***y*** in polyurethane?

	x	**y**
A	90	90
B	120	120
C	107	120
D	109.5	90

Solution:C
Around **N**: 3 bond pair and 1 lone pair
∴ shape is **trigonal pyramidal** and bond angle is **107°**
Around **C**: 3 bond pair and 0 lone pair
∴ shape is **trigonal planar** and bond angle is **120°**

6 Oxygen reacts with nitrogen monoxide in the equation shown.

$$O_2\,(g) + 2\,NO\,(g) \rightarrow 2\,NO_2\,(g)$$

In an experiment to investigate the effects of concentrations on the rate of the reaction, the following results were obtained.

Expt	$[O_2]$ / mol dm^{-3}	[NO] / mol dm^{-3}	Rate / mol dm^{-3} s^{-1}
1	1.0	1.0	0.0007
2	1.0	2.0	0.0028
3	2.0	1.0	0.0014
4	2.0	2.0	**z**

The value of **z** is

A 0.0007
B 0.0021
C 0.0056
D 0.0112

Solution:C

From expt 1 & 2, when [NO] doubles, rate increase by 4 folds.
Hence, 2nd order wrt. to [NO]

From expt.1 & 3, when $[O_2]$ doubles, rate also doubles.
Hence, 1st order wrt. to $[O_2]$.
Rate = k $[O_2]$ $[NO]^2$

Compare expt 3 & 4, when [NO] doubles, rate should increase by 4 folds.

Rate= 0.0014 x 4 = **0.0056 moldm^{-3}s^{-1}**

7 What can be deduced from the following equilibrium?

$2\,SO_2\,(g) + O_2\,(g) \rightleftharpoons 2\,SO_3\,(g) \qquad \Delta H = -98\ kJ\ mol^{-1}$

A Adding a catalyst increase the yield of SO_3 (g).
B Decreasing the pressure will cause the position of equilibrium to shift to the right.
C Decreasing the temperature will cause the position of equilibrium to shift to the left.
D The maximum mass of SO_3(g) that can be made from 64 g of SO_2(g) is 80 g

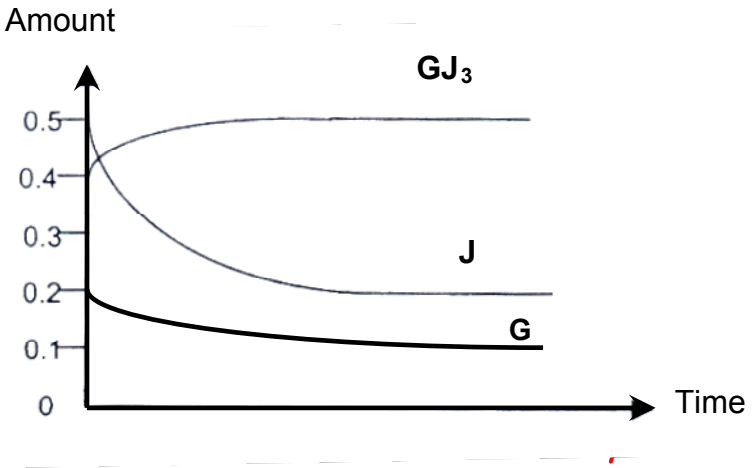
Solution: D
Adding catalyst only increase rate of forward and backward reaction equally. It does not affect the yield of SO_3.
Decreasing pressure will favour **backward** reaction which produces greater moles of gas.
Decreasing temperature will favour **forward** reaction which produces heat.

Amount of SO_2 in 64 g = 1 mol
Mole ratio: $SO_2 \equiv SO_3$
Maximum mass of SO_3 produced = 1 x (32 +16x3) = **80g**

8 The system containing **G**, **J** and $\mathbf{GJ_3}$ is allowed to reach equilibrium in a 5 dm^3 vessel at a temperature of 1000K.

$$\mathbf{G}\,(g) + 3\,\mathbf{J}\,(g) \rightleftharpoons \mathbf{GJ_3}\,(g)$$

The diagram below shows the change in number of moles of **G**, **J** and $\mathbf{GJ_3}$ with time.



What is the equilibrium constant K_c for the reaction?

A $\dfrac{0.5}{0.1\times(0.2)^3}$

B $\dfrac{0.5}{0.2\times(0.2)^3}$

C $\dfrac{0.5\times5^3}{0.1\times(0.2)^3}$

D $\dfrac{0.5\times5^3}{0.2\times(0.2)^3}$

Solution: C

$$Kc = \frac{[GJ_3]}{[G][J]^3} = \frac{(0.5/5)}{(0.1/5)(0.2/5)^3} = \frac{0.5\times5^3}{0.1\times(0.2)^3}$$

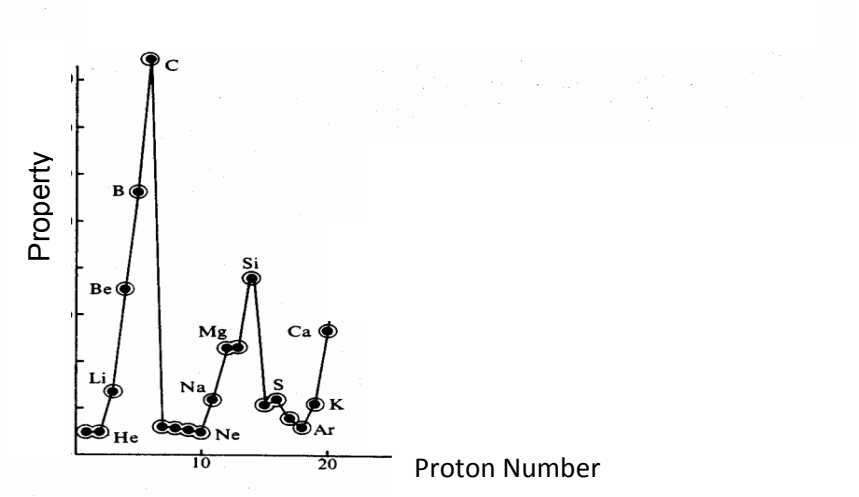
9 An enzyme was found to operate at maximum efficiency in an aqueous solution buffered at pH 5. Which of the following would give the necessary buffer solution when dissolved in 10 dm^3 of water?

A 1 mol of NaOH and 1 mol of CH_3COOH
B 1 mol of CH_3COOH and 1 mol of $CH_3COO^-Na^+$
C 1 mol of HC*l* and 1 mol of $CH_3COO^-Na^+$
D 1 mol of $CH_3COO^-NH_4^+$

Solution: B

Components of acidic buffer: weak acid and salt of conjugate base

10 The following shows the variation of a property of the first 20 elements in the Periodic Table with the proton number of the element.



What is the property?

A Atomic Radius
B First ionisation energy
C Ionic radius
D Melting point

Solution: D
The graph shows the trend in melting point of the elements.
High melting point for Group I, II and III metals as they have giant ionic structure.
High melting point for Group IV elements as they have giant molecular structure.
Low melting point for Group V to noble gases as they have simple molecular structures.

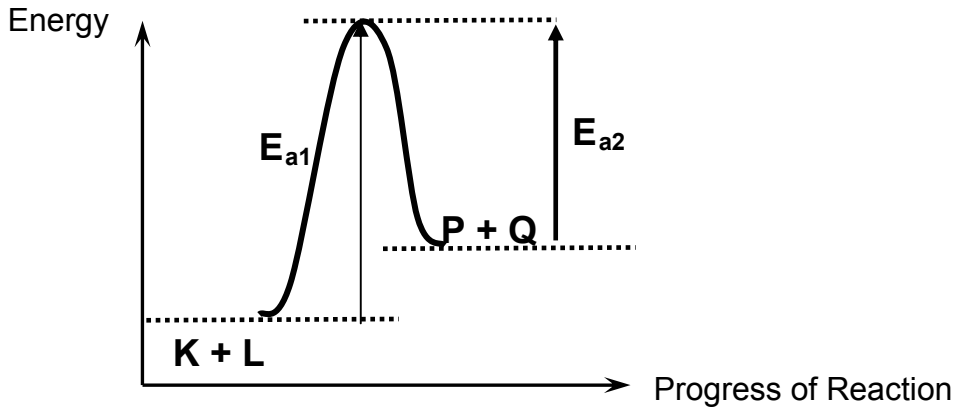
11 Which of the following elements has an oxide with a giant molecular structure and a chloride which is readily hydrolysed?

A Silicon
B Sodium
C Phosphorus
D Barium

Solution:A
SiO_2 is a giant molecular compound.

$SiCl_4$ is readily hydrolysed in water to form HCl.
$SiCl_4(l) + 2H_2O(l) \rightarrow SiO_2(s) + 4HCl(aq)$

12 A certain reversible reaction, **K** + **L** $\rightleftharpoons$ **P** + **Q**, gives the following energy profile diagram.



Which of the following statements is false?

A $E_{a1} = E_{a2} - \Delta H$
B The formation of **K** and **L** is an exothermic reaction.
C Temperature of surrounding decreases during the formation of **P** and **Q**.
D The activation energy of the backward reaction is lower than the activation energy of the forward reaction.

Solution:A

A $E_{a1} = E_{a2} - \Delta H$ ☒

It should be $E_{a1} = E_{a2} + \Delta H$

B The formation of **K** and **L** is an exothermic reaction. ☑

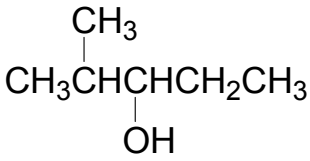
Forward reaction is endothermic ($\Delta H > 0$) and backward reaction is exothermic ($\Delta H < 0$)

C Temperature of surrounding decreases during the formation of **P** and **Q**. ☑

Forward reaction is endothermic. System absorbs heat from surroundings thus surrounding temperature decreases.

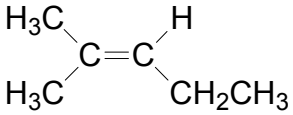
D The rate of reaction for the backward reaction is higher than the forward reaction.☑ E_{a1} (activation energy for forward reaction) is higher than E_{a2} (activation energy for backward reaction). A reaction with a lower E_a will take place faster (faster rate) and vice-versa.

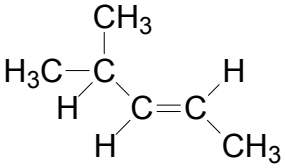
13 How many alkenes (including geometric isomers) can be obtained when 2-methylpentan-3-ol undergoes dehydration?

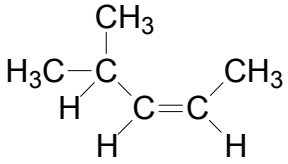


A 1
B 2
C 3
D 4

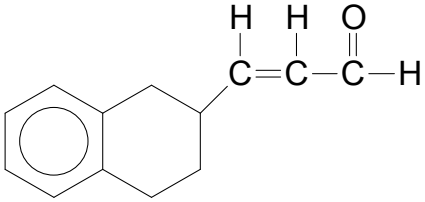
Solution: C
3 Possible isomers:





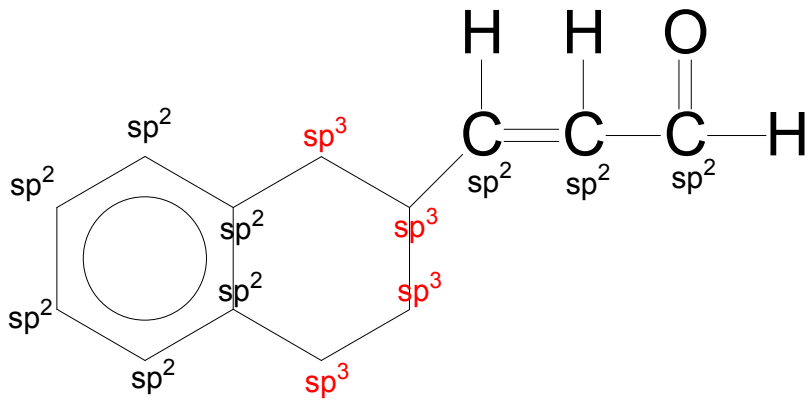


14 Identify the number of sp^2 and sp^3 carbon atoms in the given structure:



	sp^2	**sp^3**
A	8	5
B	9	4
C	2	5
D	3	4

Solution: B



All carbon atoms in benzene ring, C=C, C=O are sp^2 hybridised (total: 9)
Remaining carbon atoms in the cyclohexane are sp^3 hybridised (total: 4)

15 Which of the following statements is correct?

A But-2-ene undergoes electrophilic substitution with aqueous bromine to form alcohols.
B The halogen molecule undergoes heterolytic fission during free radical substitution.
C $CH_3CH_2CH_2OH$ is the major product formed when propene reacts with water under suitable conditions.
D Ethane reacts with chlorine in the presence of light to form CH_3CHCl_2.

Solution:D

A But-2-ene undergoes electrophilic addition with aqueous bromine to form alcohols.
B The halogen molecule undergoes homolytic fission during free radical substitution.
C $CH_3CH(OH)CH_3$ is the major product formed when propene reacts with water under suitable conditions.

16 Fly paper is used as a non-toxic method of trapping houseflies. To increase its effectiveness and attractiveness, *Muscalure*, which is a fly sex pheromone, is added to the paper during the manufacturing process.

Muscalure has the following structure:

$$CH_3(CH_2)_7CH=C(CH_3)(CH_2)_{12}CH_3$$

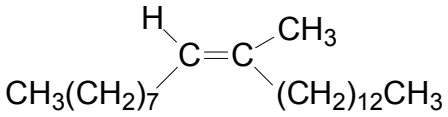
Which of the following statements about *Muscalure* is **incorrect**?

A In the presence of excess bromine and uv light, it undergoes free radical substitution.
B It exists as a pair of geometrical isomers.
C It reacts with HBr to form single product only.
D It can be extracted from the fly paper by soaking the paper in benzene.

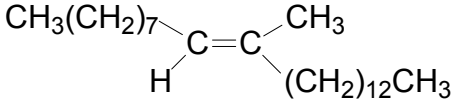
Solution: C

A Alkyl side chains undergo free radical substitution in presence of Br_2 and uv light.☑

B It exists as a pair of geometrical isomers ☑



cis-isomer

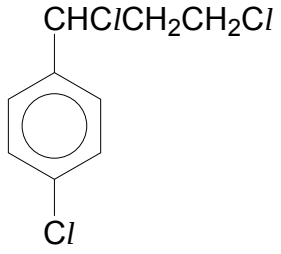


trans-isomer

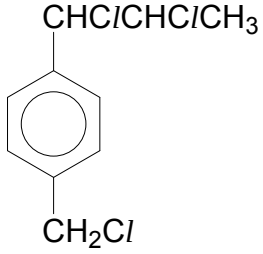
C It reacts with HBr to form single product only ☒
2 products could be formed (major & minor) according to Markonikov's rule.

D It can be extracted from the fly paper by soaking the paper in benzene ☑
Muscalure is an organic compound and hence soluble in benzene (organic solvent) as favourable Van der Waals' forces of attraction can be formed between solute and solvent molecules.

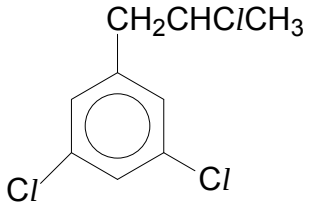
17 Experiments are carried out on three compounds: **R**, **S** and **T.**



R



S



T

A sample of 0.01 mol of each compound is refluxed with 40 cm^3 of 1 mol dm^{-3} of aqueous sodium hydroxide in excess. Excess aqueous silver nitrate is added to the resulting mixture in each case and the mass of the precipitate weighed.

What is the mass in grams, of the precipitate formed by each compound?

	R	S	T
A	4.31	4.31	4.31
B	2.87	2.87	1.44
C	2.87	4.31	1.44
D	1.44	4.31	1.44

Solution: C

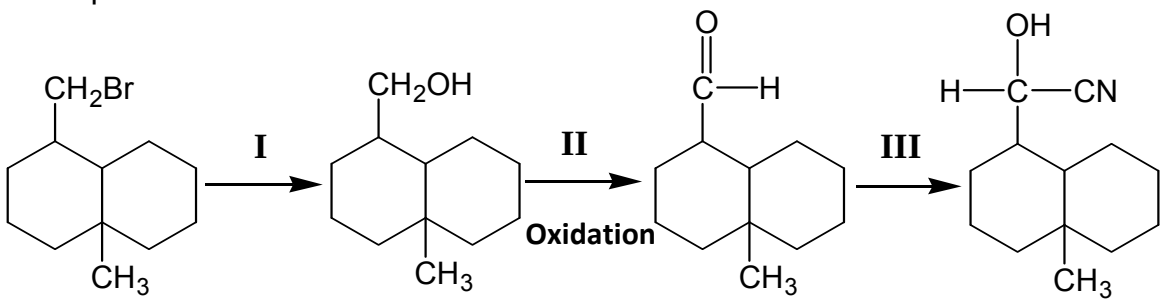
Halogenoarenes do not undergo nucleophilic substitution but halogenoalkanes do.
$R\text{-}CH_2X + NaOH \rightarrow R\text{-}CH_2OH + NaX$
$X^- + Ag^+ \rightarrow AgX$ (ppt)
For **P**: 2 chlorine atoms will be substituted
For **Q**: 3 chlorine atoms will be substituted
For **R**: 1 chlorine atom will be substituted
Mass of ppt: **R< P < Q**

18 Which reagent could be used to distinguish between pentan-2-ol and pentan-2-one?

A aqueous bromine
B alkaline aqueous iodine
C acidified potassium manganate(VII)
D sodium carbonate

Solution: C
Both do not react with aqueous bromine.
Both react with aq I_2.
Both do not react with Na_2CO_3.
Pentan-2-ol, a 2^o alcohol can be oxidized by acidified potassium manganate(VII) to form a ketone.

19 A 3-step reaction scheme is shown below.



Which one of the following correctly describes the types of organic reactions for steps **I** and **III**?

	Step **I**	Step **III**
A	Electrophilic substitution	Nucleophilic addition
B	Electrophilic substitution	Electrophilic addition
C	Nucleophilic substitution	Nucleophilic addition
D	Nucleophilic substitution	Electrophilic substitution

Solution:C

Step **I**: OH^- (nucleophile) substitutes Br^-.

Step **III**: HCN (CN^-: nucleophile) adds to the aldehyde.

20 An ester **U** has the following chemical formula: $C_3H_7COOC_3H_7$. Which pair of compounds *cannot* be used to produce **U** in the presence of concentrated sulphuric acid?

A $CH_3CH_2CH_2COOH$ and $(CH_3)_2CHOH$
B $(CH_3)_2CHCOOH$ and $CH_3CH_2CH_2OH$
C CH_3CH_2COOH and $CH_3CH_2CH_2OH$
D $(CH_3)_2CHCOOH$ and $(CH_3)_2CHOH$

Solution: C

Having a structural formula means that the structure can be of $CH_3CH_2CH_2$- OR $(CH_3)_2CH$-.

For option C, the acid being used should be a 4-C carboxylic acid, and not propanoic acid.

For **questions 21 – 30**, one or more of the numbered statements **1** to **3** may be correct. Decide whether each of the statements is or is not correct. The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

No other combination of statements is to be used as correct response.

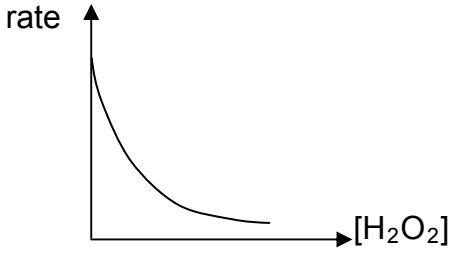
21 Which of the following molecules are **not** polar?

1 CO_2 , CH_4
2 CCl_4 , $AlCl_3$
3 SF_4 , F_2O

Solution: B (1 and 2 only are correct)
SF_4 and F_2O have **non-zero net dipole moment**.
SF_4 : Square planar (4 bond pairs & 2 lone pairs)
F_2O: Bent (2 bond pairs & 2 lone pairs)

22 Which graph would confirm that the rate of decomposition of hydrogen peroxide is first order with respect to the concentration of hydrogen peroxide?

1



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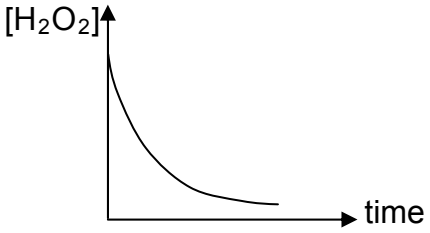
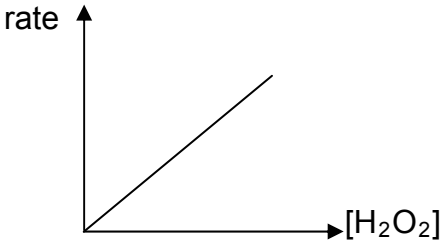


3



Solution: C (2 & 3 only are correct)
Rate = k $[H_2O_2]$
Rate vs $[H_2O_2]$ should be a linear graph passing through the origin.
$[H_2O_2]$ vs. time should be a downwards sloping curve with constant half-life.

23 Which of the following are correct descriptions of a weak acid?

1 It has low pK_a value.
2 It has a relatively low electrical conductivity in dilute solutions.
3 Its conjugate base is strong.

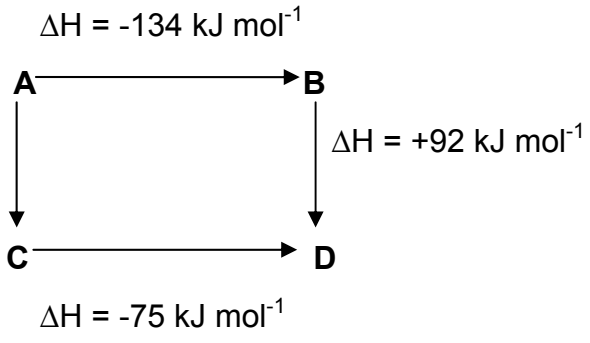
Solution: C
1 low pKa = high Ka value = stronger acid (wrong answer)
2 weak acid = less ions dissociated in solution = low electrical conductivity (correct)
3 weak acid will give rise to a strong conjugate base (correct)

24 Which of the following oxides can dissolve in aqueous sodium hydroxide?

1 Al_2O_3
2 SiO_2
3 MgO

Solution: B
1 $Al_2O_3(s) + 2NaOH(aq) + 3H_2O(l) \rightarrow 2Na[Al(OH)_4]\ (aq)$
2 $SiO_2\ (s) + 2NaOH\ (aq) \rightarrow Na_2SiO_3\ (aq) + H_2O\ (l)$
3 MgO is a basic oxide and would not react with a base.

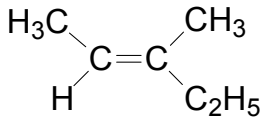
25 The diagram below illustrates the energy changes for a set of reactions. Which of the following statement(s) is/are correct?



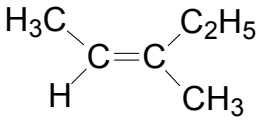
1 The enthalpy change for the transformation of **D**→**A** is +42 kJ mol^{-1}.
2 The enthalpy change for the transformation of **C**→**B** is endothermic.
3 The enthalpy change for the reaction **A**→**C** is -33 kJ mol^{-1}.

Solution: D (Only 1 is correct)
1 ΔH from **A**→**D** = -134+92 = -42 kJ mol^{-1}
ΔH from **D**→**A** =-(-42) = +42 kJ mol^{-1} ☑
2 ΔH from **C**→**B** = -75-92 = -167 kJ mol^{-1} (exothermic reaction) ☒
3 ΔH from **A**→**C** + (-75) -92 = -134
ΔH from **A**→**C** = -134 + 92 + 75 = +33 kJ mol^{-1} ☒

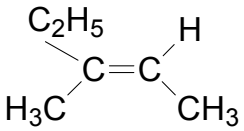
26 The four structures shown below are isomers of C_6H_{12}.



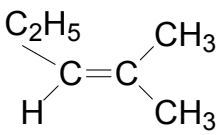
E



F



G



H

Which of the following pairs are cis-trans isomers?

1 **E** and **F**
2 **E** and **G**
3 **F** and **H**

Solution: D (Only 1 correct)
E is cis-isomer and **F** is trans-isomer
E and **G** are the same
F and **H** are structural isomers

27 2,2-dimethylpropylamine can be produced by this reaction scheme starting with compound **J**.

2,2-dimethylpropylamine

Which of the following statement(s) is / are correct?

1 **J** is $(CH_3)_3CBr$.

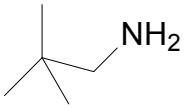
2 Conversion of **J** to **K** is a nucleophilic substitution reaction.

3 Conversion of **K** to 2,2-dimethylpropylamine could be carried out using hydrogen in the presence of nickel catalyst.

Solution: A (All correct)

1 **J** is $(CH_3)_3CBr$ ☑

$(CH_3)_3CBr \rightarrow (CH_3)_3C(CN) \rightarrow (CH_3)_3C(CH_2NH_2)$

same as 

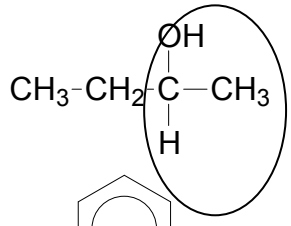
2 Conversion of **J** to **K** is a nucleophilic substitution reaction ☑
Nucleophile is CN^-

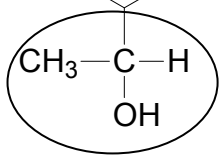
3 Conversion of **K** to 2,2-dimethylpropylamine could be carried out using hydrogen ☑
⇨Reduction of nitrile to form amine

28 Which of the following compounds forms a yellow precipitate when warmed with alkaline aqueous iodine?

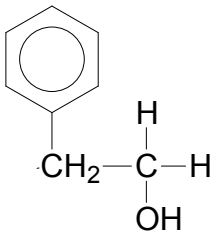
1 Butan-2-ol
2 1-phenylethanol
3 2-phenylethanol

Solution: B (1 & 2 only are correct)

1. 

2. 

3.



29 Which of the following reagents can be used to distinguish between C_6H_5CHO and $C_6H_5COCH_3$?

1 Aqueous $[Ag(NH_3)_2]^+$
2 Alkaline solution of iodine
3 2,4-dinitrophenylhydrazine

Solution: B (1 & 2 only are correct)

1 Silver mirror test: Aqueous $[Ag(NH_3)_2]^+$ is able to oxidise aldehyde (C_6H_5CHO) but not ketone ($C_6H_5COCH_3$).

2 Triiodomethane test: Alkaline solution of iodine will yield yellow precipitate of CHI_3 with $C_6H_5COCH_3$ because of $CH_3-\overset{\overset{O}{\|}}{C}-$ structure but not with C_6H_5CHO.

3 2,4-DNPH can react with both aldehyde (C_6H_5CHO) and ketone ($C_6H_5COCH_3$) to yield orange precipitate. Therefore, it cannot be used as a distinguishing test.

30 Compound **L** has the general formula of $C_nH_{2n}O_2$.

What could be its possible identity?

1 It contains an ester group
2 It contains a carboxylic acid group.
3 It contains 2 carbonyl groups.

Solution: B (Only 1 and 2 are correct)

Carbonyl groups will have the general formula $C_nH_{2n}O$. If the compound contains 2 carbonyl groups, then the general formula will be $C_nH_{2n-2}O_2$.

-END OF PAPER-