SERANGOON JUNIOR COLLEGE
General Certificate of Education Advanced Level
Higher 2

CHEMISTRY 9746/01

Prelim Examination Vetting Copy
MCQ Solutions

Mole concept (Dilution calculation, back titration)

1	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 atomic mass of **M**?	
	A	47.9
	B	54.9
	C	55.9
	D	101.0

Solution: C

Amount of NaOH = $\frac{27.5}{1000} \times 0.1 = 2.75 \times 10^{-3}$ mol

Amount of unreacted H_2SO_4 in 25.0 cm^3 of solution = 1.375 x 10^{-3} mol.

Amount of unreacted H_2SO_4 in 100 cm^3 of solution = $\frac{100}{25.0} \times 1.375 \times 10^{-3} = 5.5 \times 10^{-3}$ mol.

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 **M**O = 0.06 – 5.5x10^{-3}= 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, no of moles of **M**O in 3.920g of **M**O = 0.0545 mol

Given no. of moles of **M**O = mass of **M**O/ 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

REDOX (Use of half equation to deduce mole of reactants)

2	A commercial production of iodine involves the reduction of a solution of iodate(V) ions, IO_3^-, with the theoretical quantity of hydrogen sulphite ions, HSO_3^- in acidic condition. The hydrogen sulphite ions are oxidised to sulphate ions, SO_4^{2-} while the iodate(V) ions are reduced to iodine, I_2. Given $H_2O(l) + HSO_3^-(aq) \rightarrow SO_4^{2-}(aq) + 3H^+(aq) + 2e^-$ How many moles of hydrogen sulphite ions are needed to reduce one mole of iodate(V) ions?	
	A	0.4
	B	1
	C	2.5
	D	5

Solution: C

Reduction: IO_3^- is reduced to I_2.

Reduction half-equation: $2IO_3^-(aq) + 12H^+(aq) + 10e^- \rightarrow I_2(aq) + 6H_2O(l)$

Oxidation: HSO_3^- is oxidised to SO_4^{2-}

Oxidation half-equation: $H_2O(l) + HSO_3^-(aq) \rightarrow SO_4^{2-}(aq) + 3H^+(aq) + 2e^-$ (**x 5**)

Overall equation:

$2IO_3^-(aq) + 5HSO_3^-(aq) \rightarrow I_2(aq) + H_2O(l) + 5SO_4^{2-}(aq) + 3H^+(aq)$

Atomic Structure (deduce no of protons, electrons and neutrons in atoms or ions)

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 is isotonic and isoelectronic with respect to an atom of carbon-14?	
	A	$^{13}C^-$
	B	$^{14}N^+$
	C	$^{16}O^{2+}$

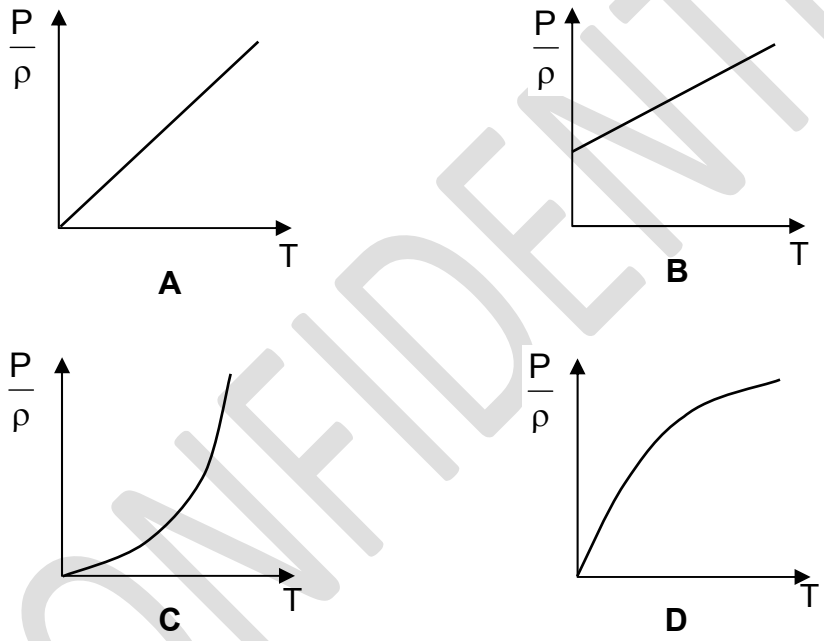
	D	$^{17}F^{+}$

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

Gas Law (Interpretation of graph)

4 Which of the following shows a graph of $\frac{P}{\rho}$ against T for an ideal gas?
(P = pressure; ρ = density; T = temperature in $^{\circ}$C).

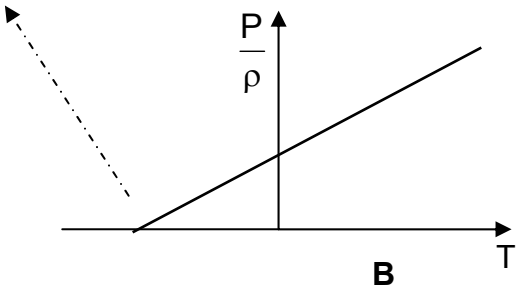


Solution: B

pV = nRT ➔ pV = $\frac{m}{Mr}$RT ➔ p =($\frac{m}{V}$)$\frac{RT}{Mr}$ ➔ $\frac{P}{\rho}$ = $\frac{RT}{Mr}$

It is a linear graph.

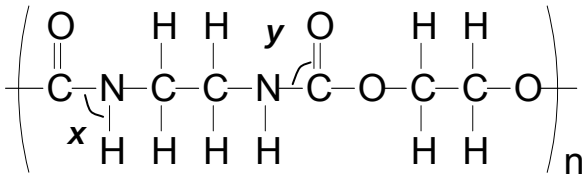
At 0^{o}C = 273K, hence p/ρ is not zero.



Since in Ideal gas equation temperature is expressed as Kelvin

$\frac{P}{\rho} = \frac{R(T+273)}{Mr}$ hence when T is at 0°C, there will be a value for $\frac{P}{\rho}$

Chemical Bonding (Identification of Bond angle)

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°**

Chemical Equilibria (Calculation of K_p)

6	Zinc oxide reacts with hydrogen according to the following equation. $ZnO\ (s) + H_2\ (g) \rightleftharpoons Zn\ (s) + H_2O\ (g)$ At temperature T and a total pressure of 10 atm, it is found that initial amounts of 1 mole each of zinc oxide and hydrogen gas produce 0.01 mole each of zinc and steam at equilibrium. What is the approximate value of K_p at temperature T?	
	A	10^{-4}
	B	10^{-2}
	C	10
	D	100

Solution: B

	$ZnO(s) + H_2(g) \rightleftharpoons Zn(s) + H_2O(g)$			
Initial no. of mol	**1**	**1**	**0**	**0**
Change in mol	**-0.01**	**-0.01**	**+0.01**	**+0.01**
Equilibrium no. of mol	**0.99**	**0.99**	**0.01**	**0.01**

[Omit ZnO and Zn in **K_p expression** as they are solid.]

$$K_p = \frac{P_{H_2O}}{P_{H_2}} = \frac{0.01/1 \times 10}{0.99/1 \times 10} = 10^{-2}$$

Reaction Kinetics

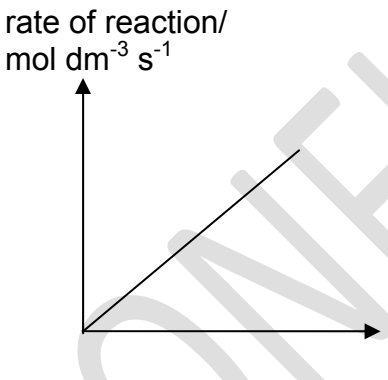
7 Hydrogen peroxide reacts with acidified iodide ions liberating iodine according to the equation below:

$$H_2O_2\,(aq) + 2H^+\,(aq) + 2I^-\,(aq) \rightarrow I_2\,(aq) + 2H_2O\,(l)$$

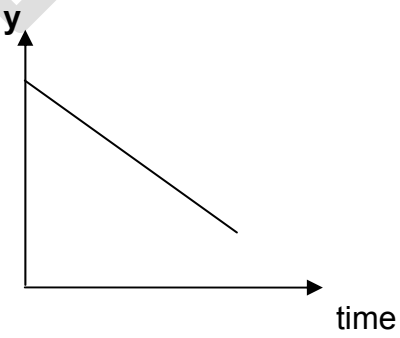
The kinetics of this reaction were investigated and it was found to have the following rate equation: rate = k $[H_2O_2]$ $[I^-]$

Two series of experiments were conducted giving rise to **Graph A** and **Graph B**.

Graph A



Graph B



Which of the following shows the correct labeling of the x-axis for **Graph A** and y-axis for **Graph B**?

		x-axis for Graph A	**y-axis for Graph B**
	A	$[H_2O_2]\,[I^-]$ / mol^2 dm^{-6}	$[H^+]$ / mol dm^{-3}
	B	$[I^-]\,[H^+]$ / mol^2 dm^{-6}	$[I_2]$ / mol dm^{-3}
	C	$[H_2O_2]$ / mol dm^{-3}	$[I^-]$ / mol dm^{-3}
	D	$[H^+]$ / mol dm^{-3}	$[H_2O_2]$ / mol dm^{-3}

Solution: A

rate = k $[H_2O_2]$ $[I^-]$

Graph of rate vs. $[H_2O_2]$ $[I^-]$ is a linear graph which passes through the origin.

Rate of reaction is independent of $[H^+]$. Thus graph of $[H^+]$ vs time is a downwards sloping straight line graph of constant gradient.

Ionic Equilibrium (Buffer Solution component)

8	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

Ionic Equilibrium (K_{sp})

9	When the concentration of Ca^{2+} ions in water is greater than 10^{-5} mol dm^{-3}, an insoluble scum would be formed with soap. To prevent scum forming with soap, what minimum mass of sodium carbonate should be added to 1 dm^3 of water? [Solubility product of $CaCO_3$ = 5.0 x 10^{-9} mol^2 dm^{-6}]	
	A	0.037 g
	B	0.042 g
	C	0.050 g
	D	0.053 g

Solution: D

The scum formed is $CaCO_3$ (s)

$CaCO_3$ (s) $\rightleftharpoons$ Ca^{2+} (aq) + CO_3^{2-} (aq)

K_{sp} of $CaCO_3$ = $[Ca^{2+}][CO_3^{2-}]$

5.0 x 10^{-9} = (10^{-5}) $[CO_3^{2-}]$ (there are presence of 10^{-5} mol dm^{-3} of Ca^{2+} present in water)

$[CO_3^{2-}] = 5.0 \times 10^{-4}$ mol dm^{-3}

Na_2CO_3 (aq) → 2 Na^+ (aq) + CO_3^{2-} (aq)

$[Na_2CO_3] = [CO_3^{2-}]$

$= 5.0 \times 10^{-4}$ mol dm^{-3}

Minimum mass of Na_2CO_3 added to 1 dm^3 of water $= 5.0 \times 10^{-4} \times (2 \times 23.0 + 12.0 + 3 \times 16.0)$

$= 0.053$ g

Thermochemistry (Calculation involving enthalpy of change of neutralisation)

10	The enthalpy change of neutralisation of dilute sulphuric acid by dilute sodium hydroxide is the heat liberated when	
	A	1 mole of H_2SO_4 reacts with ½ mole of NaOH
	B	1 mole of H_2SO_4 reacts with 1 mole of NaOH
	C	1 mole of H_2SO_4 reacts with 2 mole of NaOH
	D	½ mole of H_2SO_4 reacts with 1 mole of NaOH

Solution: D

Thermochemistry (Calculation of ΔH_{rxn} using formula method)

11	Tetrachloroethene is commonly used as a degreasing solvent. The enthalpy change for the reaction below is -878.5 kJ mol^{-1}. C_2H_4 (g) + 4HC*l* (g) + $2O_2$ (g) → C_2Cl_4 (*l*) + $4H_2O$ (*l*) Which of the following is the enthalpy change of formation of tetrachloroethene given the following information? ΔH_f (C_2H_4 (g)) = +52.3 kJ mol^{-1} ΔH_f (HC*l* (g)) = -92.3 kJ mol^{-1} ΔH_f (H_2O (*l*)) = -285.8 kJ mol^{-1}	
	A	-9.2 kJ mol^{-1}
	B	-52.2 kJ mol^{-1}
	C	-330 kJ mol^{-1}
	D	-633 kJ mol^{-1}

Solution: B

Using $\Delta H_{rxn} = \sum \Delta H_f$ (pdts) - $\sum \Delta H_f$ (rxts)

$-878.5 = [\Delta H_f (C_2Cl_4) + 4(-285.8)] – [52.3 + 4(-92.3) + 2(0)]$

ΔH_f (C_2Cl_4) = **-52.2 kJ mol^{-1}**

Electrochemistry (Concept w.r.t. direction of electron flow)

12	Given the cell diagram, Cu (s) / Cu^{2+} (aq) // Ag^+ (aq) / Ag (s) Which of the following statement is **correct**?	
	A	The mass of the silver electrode will decrease.
	B	Electrons flow from the silver electrode to the copper electrode in the external circuit.
	C	When NaOH(aq) is added to the Cu^{2+}(aq)/Cu(s) half cell, the E^{θ}_{cell} will become less positive.
	D	Replacing the Ag^+(aq)/Ag(s) half cell with Co^{2+}(aq)/Co(s) half cell will reverse the direction of electron flow in the external circuit.

Solution: D

A: The mass of silver electrode will **increase** since reduction of Ag^+ to Ag occurs.

B: Electrons flow from the **copper electrode to the Ag electrode**.

C: Upon adding NaOH(aq), $Cu(OH)_2$ will be precipitated, this causes a depletion of Cu^{2+}(aq) and by LCP, the equilibrium position of Cu^{2+} + 2e ⇌ Cu will shift left favouring oxidation procedure hence **E^{θ}_{oxd} will become less positive and since $E^{\theta}_{cell} = E^{\theta}_{red} - E^{\theta}_{oxd}$, E^{θ}_{cell} will become more positive.**

D: Co^{2+} + 2e ⇌ Co (E^{θ} = -0.28V); Cu^{2+} +2e ⇌ Cu (E^{θ} = +0.34V)

Connecting these two half cell together, Cu^{2+}/Cu will become the cathode and Co^{2+}/Co half cell become the anode thus electrons flow will be from Co electrode to Cu electrode, reversing the direction of electrons flow of the external circuit.

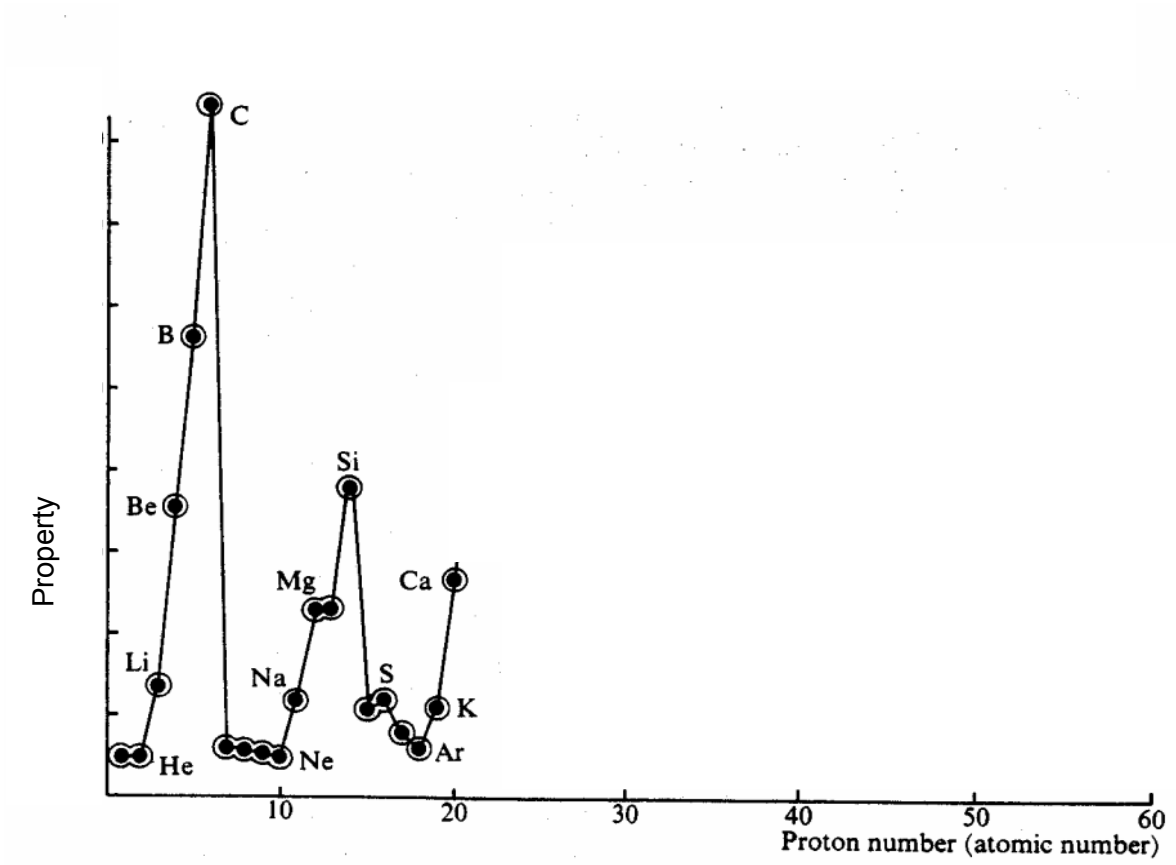
Electrochemistry (Order of reducing agent) Change to something on diaphragm cell

13	A current of 0.2 ampere passing for 5 hours through a solution of gold ions deposits a mass of 2.45 g of gold on the cathode. Which of these expressions gives the charge on a gold ion?	
	A	$\frac{2.45 \times 0.2 \times 5 \times 60 \times 60}{197 \times 96500}$
	B	$\frac{0.2 \times 5 \times 60 \times 60 \times 197}{96500 \times 2.45}$
	C	$\frac{2.45 \times 96500}{197 \times 0.2 \times 5 \times 60 \times 60}$
	D	$\frac{197 \times 0.2 \times 5 \times 60 \times 96500}{2.45}$

Solution: B

Periodic Table (Trend of melting point)

14 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 metals eg Na and Mg and low melting point for non-metals eg S and Ar.

Periodic Table (Chemical structure oxide and reaction of chloride with water)

15	Which of the following elements has an oxide with a giant structure and a chloride which is readily hydrolysed?	
	A	Silicon
	B	Sodium
	C	Phosphorus
	D	Carbon

Solution: A

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

Group II (Properties of Group II metals)

16	Which of the statements about Group II elements is **correct**?	
	A	The reducing power decreases down the group.
	B	The ionic radius increases down the group.
	C	The electronegativity increases down the group.
	D	The reactivity with water decreases down the group.

Solution: B

Down the group, reducing power increases, electronegativity decreases and reactivity with water increases.

Group II (Solubility of Group II sulphate)

17	The solubility of the Group II sulphates decreases as the proton number increases. Which factor affects this trend?	
	A	The atomic radius of the metal atom
	B	The enthalpy change of formation of the sulphate
	C	The enthalpy change of hydration of the metal ion
	D	The first ionisation energy of the metal

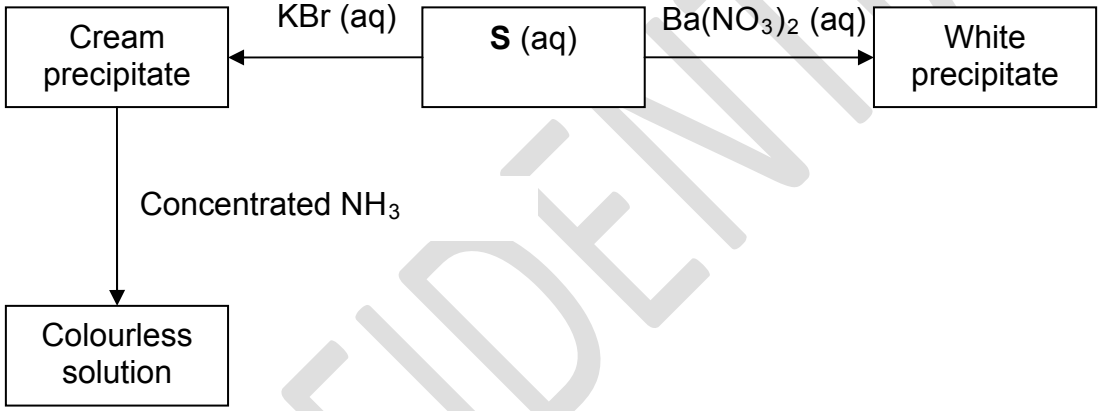
Solution: C

Solubility of the Group II metal sulphates decease down the group because:

- Ionic radius of the cation increases
- Charge density of the cation decreases
- Hence, both lattice energy and hydration energy decreases
- However, the decrease in hydration energy is more significant than the decrease in the lattice energy
- ΔH_{soln} increases

Group VII

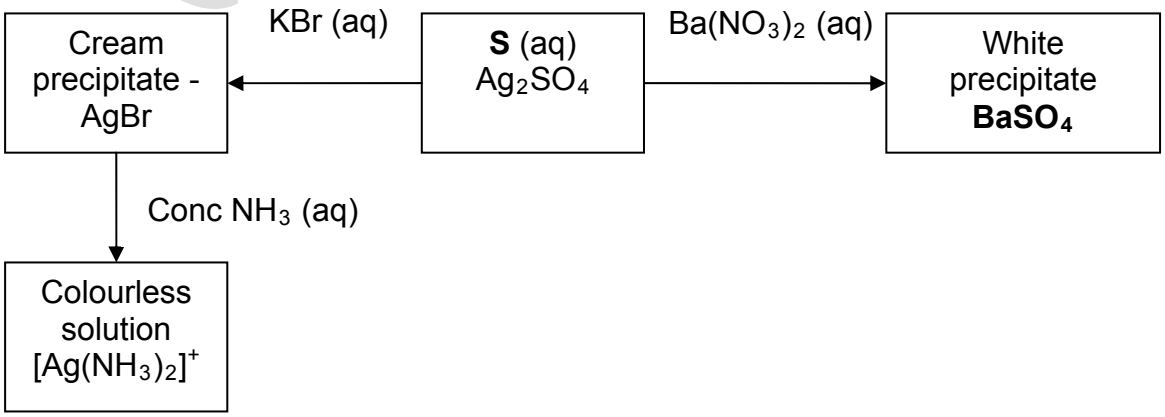
18 A solution **S** is given the following treatment:



Which one of the following could be compound **S**?

	A	$AgNO_3$
	B	Ag_2SO_4
	C	$Pb(NO_3)_2$
	D	$PbSO_4$

Solution: B



Group VII (Reaction of Conc H_2SO_4 with halides)

19	A student wrote the following description in his practical manual: "When *concentrated sulphuric acid* is added to a solution of sodium iodide, rapid evolution of *white fumes* is being observed. Subsequently, production of *reddish brown vapour* and *rotten egg smell* are being observed." Which part of the above description is **incorrect**?	
	A	The sulphuric acid used should be diluted, not concentrated
	B	The fumes should be violet, not white.
	C	The vapour should be violet, not reddish brown.
	D	The smell should be sweet smelling, not rotten egg.

Solution: C

$2\,HI\,(g) + H_2SO_4\,(aq) \rightarrow I_2\,(g) + 2H_2O\,(l) + SO_2\,(g)$

$8HI\,(g) + H_2SO_4\,(aq) \rightarrow 4I_2\,(g) + H_2S\,(g) + 4H_2O$

Iodine vapour should be violet, not reddish brown

Transition Elements
(Electronic configuration and understanding on 3d and 4s orbital energy level)

20	Which of the following transition metals in its ground state has an unpaired electron in an *s* orbital?	
	A	Chromium
	B	Cobalt
	C	Iron
	D	Manganese

Solution: A

Cr: $1s^2 2s^2 2p^6 3s^2 3p^6 3d^5 4s^1$

Due to similar energy level of the 3d and 4s orbital, an electron is transferred from the higher energy 4s orbital to the lower energy 3d orbital.

Transition Elements (Comparison of physical characteristic with Group II metals)

21 The table below lists some of the characteristics of vanadium and calcium.

Property	**Vanadium**	**Calcium**
1. Colour of Complexes/ions	Coloured	Colourless
2. Density	Low	High
3. Conductivity	Low	High
4. Oxidation State	Variable	Fixed
5. First Ionisation Energy	Lower	Higher

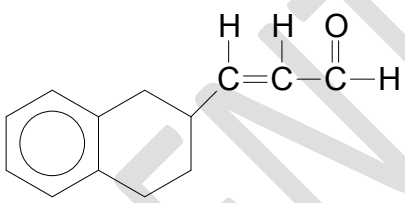
Which of the following sets of properties are **correct**?

	A	1 and 2
	B	1 and 3
	C	1 and 4
	D	1 and 5

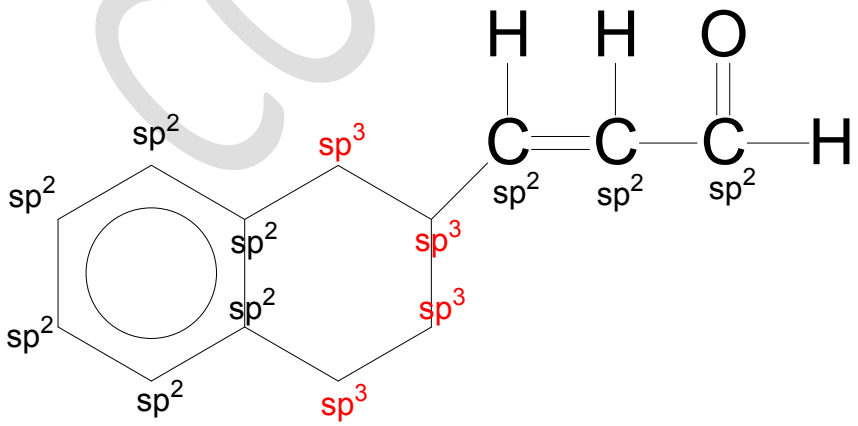
Solution: C

- Transition Metals complexes are generally coloured due to d-d transition.
- Density of transition metal is high as the atomic radius of the transition metals are smaller and thus they pack closer to each others.
- Transition metals are better conductor of electricity as there are more free mobile electrons in the sea of delocalised electrons.
- Transition metals exhibit variable oxidation state due to the presence of empty 3d orbital.
- 1^{st} IE of transition metals are higher as they are smaller in atomic size.

Introduction to Organic Chemistry (Hybridisation)

22	Identify the number of sp^2 and sp^3 hybridised carbon atoms in the given structure: 		
		sp^2	**sp^3**
	A	2	5
	B	3	4
	C	8	5
	D	9	4

Solution: D



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)

Alkanes/Alkenes (Free Radical Substitution)

23	Which of the following is the propagation step in the reaction between ethane and bromine in the presence of ultraviolet light?	
	A	$Br_2 \rightarrow 2Br\bullet$
	B	$CH_3CH_2\bullet + Br\bullet \rightarrow CH_3CH_2Br$
	C	$CH_3CH_2\bullet + HBr \rightarrow CH_3CH_2Br + H\bullet$
	D	$CH_3CH_2\bullet + Br_2 \rightarrow CH_3CH_2Br + Br\bullet$

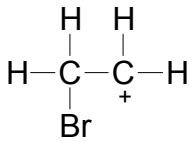
Solution: D

A is initiation step; **B** is termination step; **C** is not a free radical substitution equation; only **D** is propagation.

Alkanes/Alkenes (Electrophilic Addition)

24	Ethene reacts with bromine to form dibromoethane. Which of the following best describes the organic intermediate in this reaction?	
	A	The shape about each carbon in the intermediate is trigonal planar.
	B	It has a negative charge.
	C	It is an electrophile.
	D	It is a free radical.

Solution: C



since $\overset{\delta+}{Br} - \overset{\delta-}{Br}$, the electrophile, Br atom will be added to the alkene forming the carbocation intermediate.

Halogenoalkanes (Ease of Hydrolysis of R-X)

25	Which sequence shows the increasing ease of hydrolysis?	
	A	$C_6H_5Br > C_6H_5CH_2Cl > CH_3CH_2COCl > CH_3CH_2I$
	B	$CH_3CH_2COCl > CH_3CH_2I > C_6H_5CH_2Br > C_6H_5CH_2Cl$
	C	$C_6H_5Cl > CH_3COCH_2Cl > C_6H_5CH_2Br > CH_3CH_2I$
	D	$C_6H_5Br > CH_3CH_2Cl > C_6H_5CH_2I > CH_3CH_2COCl$

Solution: B

RCOC*l* undergo hydrolysis most readily.

C_6H_5X do not undergo hydrolysis.

Ease of hydrolysis of C-X bond : C-C*l* < C-Br < C-I

Hydroxyl Compounds (Chemical Test involving alcohol and ketone)

26	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

A: Both do not react with aqueous bromine.

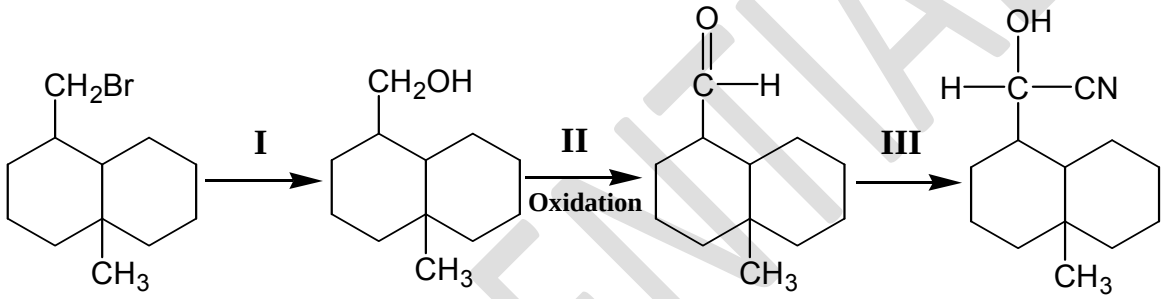
B: Both react with aq I_2.

C: Pentan-2-ol, a 2^o alcohol can be oxidized by acidified potassium maganate(VII) to form a ketone.

D: Both do not react with Na_2CO_3.

Carbonyl Compounds (Nucleophilic addition)

27 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^-.
StepIII: HCN (CN^-: nucleophile) adds to the aldehyde

Carboxylic Acid/Derivatives (Hydrolysis of Ester)

28 An ester **S** has the following chemical formula: $C_3H_7COOC_3H_7$
Which pair of compounds can be produced when **S** is refluxed with dilute sulphuric acid?

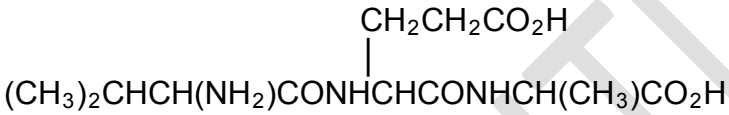
	A	$CH_3CH_2CH_2COOH$ and $(CH_3)_2CO$
	B	$(CH_3)_2CHCOOH$ and $CH_3CH_2CH_2OH$

	C	CH_3CH_2COOH and $CH_3CH_2CH_2OH$
	D	$(CH_3)_2CHCOCl$ and $(CH_3)_2CHOH$

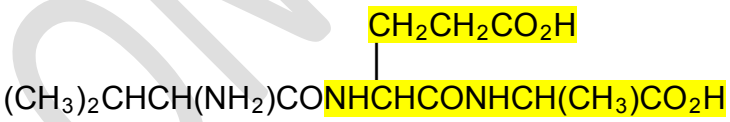
Solution: B

Having a structural formula means that the structure can be of $CH_3CH_2CH_2$- OR $(CH_3)_2CH$-.
For option A, ketone will not be produced.
For option C, the acid produced should be a 4-C carboxylic acid, and not propanoic acid.
For option D, acid chloride will not be produced after acidic hydrolysis

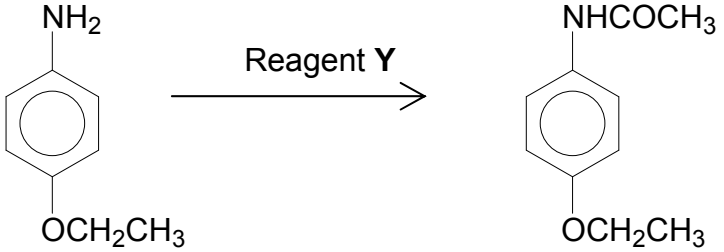
Nitrogen Compounds (Hydrolysis)

29	Partial hydrolysis of insulin, the hormone essential for carbohydrate metabolism gives the following tripeptide.  Insulin Which compound could be obtained by further hydrolysis of this tripeptide?	
	A	$CH_3CH(CO_2H)_2$
	B	$(CH_3)_2CHCH(NH_2)CONH_2$
	C	$H_2NCONHCH(CH_2CH_2CO_2H)CO_2H$
	D	$H_2NCH(CH_2CH_2CO_2H)CONHCH(CH_3)CO_2H$

Solution: D



Nitrogen Compounds (Reaction of Phenylamine)

30	The painkiller Phenacetin can be made as follows:  Phenacetin

	What could be the reagent **Y**?	
	A	$CH_3CH_2NH_2$
	B	CH_3COCH_3
	C	CH_3COOH
	D	CH_3COCl

Solution: D

Amine can only react with acid chloride to from amide. Cannot use carboxylic acid

For **questions 31 – 40**, 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.

Atoms, Molecules and Stoichiometry

31	Carbon disulphide, CS_2, is a volatile flammable liquid used in the manufacture of cellophane. On combustion, CS_2 is oxidised as follows. $CS_2\ (g) + 3O_2\ (g) \rightarrow CO_2\ (g) + 2SO_2\ (g)$ Which of the following statement(s) may be reflected from the above equation?	
	1	If 20 cm^3 of CS_2 is reacted with 100 cm^3 of oxygen, 60% of the final volume of gas will dissolved in alkali
	2	38.1 g of CS_2 will react exactly with 33.6 dm^3 of O_2 under standard temperature and pressure.
	3	When 30 cm^3 of CS_2 was reacted with 60 cm^3 of oxygen, 30 cm^3 of CO_2 will be produced.

Solution: B (1 & 2 only)

1. $CS_2\ (g) + 3O_2\ (g) \rightarrow CO_2\ (g) + 2SO_2\ (g)$
20 cm^3 60cm^3 20cm^3 40cm^3

Volume of gas remaining after reaction = (100 – 60) + 20 + 40 = 100 cm^3
Final volume of gas dissolved in alkali = vol of CO_2 + SO_2 = 60 cm^3
% Final volume of gas dissolved in alkali = 60%

2. Amount of CS_2 = 0.5 mol, Amount of O_2 = 1.5 mol
Thus Statement 2 is correct.

3. CS_2 (g) + $3O_2$ (g) → CO_2 (g) + $2SO_2$ (g)
30 cm^3 90 cm^3 required
Only 60 cm^3 available

Limiting reagent in this case turn out to be O_2
Amount of CO_2 produced = 60/3 = 20 cm^3 (not 30 cm^3)

Thermochemistry (change to something on thermodynamics)

32	Which of the following process(es) has/have a positive change in the entropy?	
	1	N_2 gas at 10 atm → N_2 gas at 1 atm
	2	Copper + Zinc → Brass
	3	Graphite → Diamond

Solution: B (1 and 2 only)

1 Positive. There is an expansion of gas

2 Positive. Entropy will increase as there are greater number of configuration.

3 Negative. Diamond is a harder solid and would be expected to have more restricted atomic motions as compared to graphite.

Electrochemistry (Predicting feasibility of reaction base on redox potential)

33 Some standard redox potential (E^θ) values are given in the table below.

Electrode reaction	E^θ/*V*
Fe^{3+} (aq) + e ⇌ Fe^{2+} (aq)	+0.77
Sn^{4+} (aq) + 2e ⇌ Sn^{2+} (aq)	+0.15
Ce^{4+}(aq) + e ⇌ Ce^{3+} (aq)	+1.45

Predict which of the following reactions would occur under standard conditions.

	1	Ce^{4+} (aq) + Fe^{2+} (aq) → Ce^{3+} (aq) + Fe^{3+} (aq)
	2	Sn^{2+} (aq) + $2Fe^{3+}$ (aq) → Sn^{4+} (aq) + $2Fe^{2+}$ (aq)
	3	$2Ce^{4+}$ (aq) + Sn^{2+} (aq) → $2Ce^{3+}$ (aq) + Sn^{4+} (aq)

Solution: A
1: E^θ_{cell} = +1.45 – 0.77 = +0.68 V (>0)

2: E^{θ}_{cell} = +0.77 – 0.15 = +0.62 V (>0)
3: E^{θ}_{cell} = +1.45 – 0.15 = +1.30 V (>0)

Group II (Thermal Stability of Group II nitrate)

34	Anhydrous calcium nitrate and anhydrous magnesium nitrate both decompose on heating, producing nitrogen dioxide and oxygen gas. Which of the following statement(s) is/are true about the decomposition reactions mentioned above?	
	1	Both nitrates leave a residue of metal oxide.
	2	A lower temperature was needed to produce nitrogen dioxide and oxygen from magnesium nitrate than calcium nitrate.
	3	The volume of oxygen produced is half the volume of nitrogen dioxide produced for both nitrates.

Solution: B (1 and 2)

$$2Mg(NO_3)_2\,(s) \longrightarrow 2MgO(s) + 4NO_2(g) + O_2(g)$$
$$2Ca(NO_3)_2\,(s) \longrightarrow 2CaO(s) + 4NO_2(g) + O_2(g)$$

Both form either MgO or CaO.

Thermal stability increase down the group, hence a lower temperature is required to decompose $Mg(NO_3)_2$

Oxygen produced from the decomposition is one quarter the volume of nitrogen dioxide produced.

Group VII (Oxidising Power of halogens)

35 The results of experiments in which the halogens $\mathbf{X}_2$, $\mathbf{Y}_2$ and $\mathbf{Z}_2$ were added to separate aqueous solutions of $\mathbf{X}^-$, $\mathbf{Y}^-$ and $\mathbf{Z}^-$ ions are shown in the

	$\mathbf{X}^-$	$\mathbf{Y}^-$	$\mathbf{Z}^-$
$\mathbf{X}_2$	No reaction	No reaction	$\mathbf{X}^-$ formed
$\mathbf{Y}_2$	$\mathbf{Y}^-$ formed	No reaction	$\mathbf{Y}^-$ formed
$\mathbf{Z}_2$	No reaction	No reaction	No reaction

	Which of the following statements correctly account for the observations?	
	1	The order of oxidising power in increasing order is $\mathbf{Z}_2 < \mathbf{X}_2 < \mathbf{Y}_2$.
	2	$\mathbf{Y}^-$ is a weaker reducing agent than $\mathbf{Z}^-$.
	3	$\mathbf{X}^-$ is the weakest reducing agent.

Solution : B (1 and 2)

X can be seen as Br, **Y** can be seen as C*l*, and Z can be seen as I

1 The order of oxidizing power in increasing order is $I_2 < Br_2 < Cl_2$.

2 Cl^- is a weaker reducing agent than I^-.

3 Cl^- is the weakest reducing agent

Transition elements

36	Which of the following statement(s) is/are true?	
	1	The electronic configuration of the iron cation in the metal complex $Fe(CN)_6^{4-}$ is $[Ar]3d^6$.
	2	The Zn^{2+} ions are coloured due to ability of the electrons to undergo d-d transition.
	3	Fe exhibits variable oxidation state due to the availability of vacant s, p and d orbitals.

Solution: D (1 only)

Statements 2 and 3 are wrong:
Zn^{2+} has no electrons that can undergo d-d transition thus its solution will not be coloured.

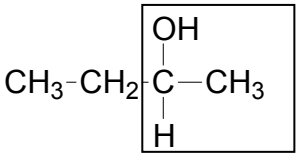
Fe exhibits variable oxidation state due to the availability of vacant **<u>p and d orbitals</u>**

Hydroxyl Compounds (Iodoform test)

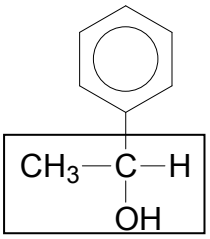
37	Which of the following compound(s) forms a yellow precipitate when warmed with alkaline aqueous iodine?	
	1	butan-2-ol
	2	1-phenylethanol
	3	2-phenylethanol

Solution: B (1 and 2)

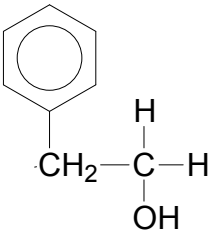
1.



2.



3.



Carbonyl Compound

(Reaction of Carbonyl compound with Tollen's, Brady's reagent and iodoform test)

38	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 and 2)

1 Silver mirror test: Aqueous $[Ag(NH_3)_2]^+$, Tollen's reagents 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.

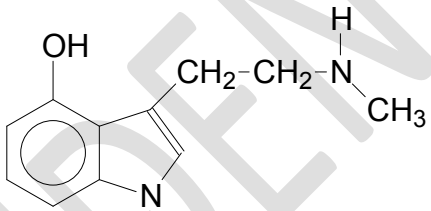
Carboxylic Acids/Derivatives

39	It has been noted that prolonged exposure of wine to the atmosphere will result in the wine becoming "vinegary". Therefore, wineries attempt to prevent such exposure by storing the wine in a mixture of carbon dioxide and nitrogen. How does this mixture prevent the "vinegary" taste from occurring?	
	1	Oxidation of ethanol into ethanoic acid will be prevented.
	2	The acidity of the wine will be decreased.
	3	The amount of carbon dioxide dissolved in the wine will be increased.

Solution: D (1 only)

Statement 2 does not answer the question as carbon dioxide and nitrogen cannot react with ethanoic acid in order to decrease the ethanoic acid present in the wine. The mixture only prevents oxygen from getting into contact with ethanol.
Statement 3 is only a factual statement with no chemistry behind the explaining of the method adopted.

Nitrogen Compounds

40	*Psilocin* is a psychedelic mushroom alkaloid which is the active compound that produces hallucinations from ingesting "magic mushrooms" and amplifies sensory experience. Compound **X** is a derivative of *Psilocin*.  **X** Which of the following statement(s) is/are true for compound **X**?	
	1	It gives white fumes with CH_3COCl.
	2	It dissolves in both aqueous acids and alkalis.
	3	The nitrogen containing group in the ring has a lower pK_b than the nitrogen containing group in the side chain.

Solution: B

The phenol group and amine group can each with CH_3COCl.

Phenol group is acidic and amine groups are basic, hence **X** can react with both acids and alkalis.

The nitrogen containing group in the ring is attached to benzene ring which will cause the lone pair on N to be delocalized into the ring, hence making it less basic. The nitrogen containing group in the side chain is attached to alkyl

-END OF SOLUTIONS