2024 JC 2 H2 Chemistry Prelim Exam Paper 1 Worked Solutions

1	D	The decomposition involves: $n \rightarrow p^+ + e^-$ where the newly-formed proton stays in the nucleus. As the proton number of the atom increases by 1 following the decomposition, the element will no longer be the same. Options A and C are eliminated. Option D involves an increase in proton number by 1 going from K to Ca, hence it is the correct answer.
2	С	Option A:
		By definition, one mole of a substance contains exactly 6.02 \times 10^{23} (or Avogadro number) elementary entities.
		Option A is incorrect because of the phrase "same number of atoms as there are in 12.000 g of carbon-12".
		Option B:
		By definition, relative isotopic mass (A_r) is the mass of one mole of atoms of an isotope (of a certain element) relative to $\frac{1}{12}$ the mass of one mole of ^{12}C
		atoms.
		"average mass of all isotopes of lithium".
		Option C:
		By definition, relative atomic mass (A_r) is the average mass of one mole of atoms of an element relative to $\frac{1}{12}$ the mass of one mole of ¹² C atoms.
		Note that some textbooks define relative atomic mass as "the average mass of one atom of an element relative to $\frac{1}{12}$ the mass of one ¹² C atom".
		Hence, option C is correct.
		Option D:
		By definition, relative molecular (M_r) mass is the average mass of one mole
		of molecules relative to $\frac{1}{12}$ the mass of one mole of ¹² C atoms.
		Option D is incorrect because in the formula given, the numerator used is "average mass of one atom of E".

3	С	Amount of $CO_2 = \frac{48.0}{24\ 000} = 0.00200 \text{ mol}$
		Amount of sodium percarbonate = $0.100 \times \frac{10.0}{1000} = 0.00100$ mol
		$(Na_2CO_3)_x \bullet_y(H_2O_2) : CO_2$
		x : 1
		0.00200 : 0.00100
		2:1
		Therefore, x = 2
		Amount of $H_2O_2 = 0.00100y$ mol
		Amount of KMnO ₄ = $0.0500 \times \frac{24.0}{1000}$ = 0.00120 mol
		Given the ratio is 2 : 5
		$\frac{0.00120}{0.00100y} = \frac{2}{5}$
		y = 3
		Therefore, $\frac{y}{x} = \frac{3}{2}$
4	D	A: Due to the overlap of unhybridised 2p orbitals, mobile delocalised electrons are found in the lattice structure.
		B: Each carbon atom forms 3 sigma bonds with 3 other carbon atoms.
		C: Instantaneous dipole-induced dipole interactions exist between each graphite plane.
		D: Conduction of electricity occurs due to the overlap of unhybridised 2p orbitals. The overlapping occurs <u>perpendicular</u> to the axis of the unhybridised 2p orbitals.



8	В	Option A is incorrect:
		ΔH_{soln} does not accurately predict the solubility of a substance. Generally, the more negative ΔH_{soln} is, the more soluble the substance; the more positive ΔH_{soln} is, the less soluble the substance.
		Option B is correct: $\Delta H_{\text{soln}} = -\text{LE} + 2\Delta H_{\text{hyd}}(\text{Hg}^{+}) + \Delta H_{\text{hyd}}(\text{SO}_{4}^{2-})$ $= -(-2127) + 2(-625) + (-1160)$ $= -238 \text{ kJ mol}^{-1}$
		Option C is incorrect:
		Magnitude of lattice energy (LE) $\propto \left \frac{Z^+ \times Z^-}{r^+ + r^-} \right $
		Since ionic radius of Hg ⁺ > Cd ⁺ , the lattice energy of Hg ₂ SO ₄ should be less exothermic than that of Cd ₂ SO ₄ .
		Option D is incorrect:
		The magnitude of ΔH_{hyd} is dependent on the charge density of the ion. Since ionic radius of Hg ⁺ > Cd ⁺ , Hg ⁺ has a lower charge density and less exothermic ΔH_{hyd} than Cd ⁺ .
9	A	Option 1 is correct: $\Delta S > 0$ due to mixing of particles. When ionic solids dissolve in water, entropy increases because the ordered ionic lattice is broken up and the ions are then free to move in solution.
		Option 2 is correct: $\Delta S > 0$ due to change in phase. When the solvent evaporates (a liquid becomes a gas), particles move randomly in all directions, and there are more ways to arrange the particles and distribute the energy. Furthermore, the large increase in volume going from a liquid to gas also leads to an increase in entropy.
		Option 3 is correct: $\Delta S > 0$ due to mixing of particles. When pure solvent particles pass through the membrane into the solution, the particles mix together towards increased disorder.

10	А	Let the initial [A] and [B] be x:
		Rate = $k[A][B]^2 = k(x^3) = y$
		After compression to 0.25V:
		Initial [A] = [B] = 4x
		Rate = $k(4x)(4x)^2 = k(64x^3) = 64y$
11	С	A – (Theoretically possible, but not the best answer) This could theoretically be used to determine change in [H ⁺] over time, and when [H ⁺] value is plotted against time, this would allow us to detect if it's 0 th order (straight line graph) or 1 st order (curve with constant half-life) but will not be able to determine 2 nd or higher orders of reaction.
		B – (Incorrect) This can let us determine the order of reaction with respect to ethanamide, and not H^+ since $[H^+]$ is the same for all experiments
		C – (Best answer) This would allow us to determine initial rate of reaction at different [H ⁺] and this data will allow us to determine order of reaction with respect to H ⁺
		$D-$ (Theoretically possible, but not the best answer) Similar to option A, this can be used to determine change in $[H^{+}]$ over time.
12	В	Option A is correct: Anionic size decreases in the order of $P^{3-} > S^{2-} > Cl^{-}$.
		Option B is incorrect. The element with the highest melting point is silicon
		which has giant covalent structure.
		which has giant covalent structure. Option C is correct: Aluminium has giant metallic lattice structure. Due to the highest number of delocalised valence electrons (per atom), aluminium has the highest electrical conductivity.
		which has giant covalent structure. Option C is correct: Aluminium has giant metallic lattice structure. Due to the highest number of delocalised valence electrons (per atom), aluminium has the highest electrical conductivity. Option D is correct: Sulfur exists as S_8 molecules.
13	A	 Which has giant covalent structure. Option C is correct: Aluminium has giant metallic lattice structure. Due to the highest number of delocalised valence electrons (per atom), aluminium has the highest electrical conductivity. Option D is correct: Sulfur exists as S₈ molecules. Statement 2 is correct and Statement 3 is incorrect.
13	A	which has giant covalent structure. Option C is correct: Aluminium has giant metallic lattice structure. Due to the highest number of delocalised valence electrons (per atom), aluminium has the highest electrical conductivity. Option D is correct: Sulfur exists as S ₈ molecules. Statement 2 is correct and Statement 3 is incorrect. Since C <i>l</i> ⁻ and Br ⁻ are spectator ions, the ionic equation is the same for both, Ag ⁺ (aq) + 2NH ₃ (aq) = [Ag(NH ₃) ₂] ⁺ (aq).
13	A	Spheric D is incorrect. The element with the highest metallic point is smooth, which has giant covalent structure. Option C is correct: Aluminium has giant metallic lattice structure. Due to the highest number of delocalised valence electrons (per atom), aluminium has the highest electrical conductivity. Option D is correct: Sulfur exists as S ₈ molecules. Statement 2 is correct and Statement 3 is incorrect. Since C <i>l</i> ⁻ and Br ⁻ are spectator ions, the ionic equation is the same for both, $Ag^+(aq) + 2NH_3(aq) = [Ag(NH_3)_2]^+(aq)$. Therefore, $\Delta G_2 = \Delta G_4$
13	A	Spheric B is incorrect. The element with the highest metally point is shown, which has giant covalent structure. Option C is correct: Aluminium has giant metallic lattice structure. Due to the highest number of delocalised valence electrons (per atom), aluminium has the highest electrical conductivity. Option D is correct: Sulfur exists as S ₈ molecules. Statement 2 is correct and Statement 3 is incorrect. Since Cl^- and Br^- are spectator ions, the ionic equation is the same for both, $Ag^+(aq) + 2NH_3(aq) = [Ag(NH_3)_2]^+(aq)$. Therefore, $\Delta G_2 = \Delta G_4$ Statement 4 is correct. Since $AgCl$ is soluble in $NH_3(aq)$ while AgBr is only soluble in concentrated $NH_3(aq)$. Therefore, $\Delta G_1 < \Delta G_3$.

14	С	Pressure:
		There are three moles of gaseous reactants and only one mole of gaseous product. An increase in pressure will cause the POE to shift right and favour the forward reactant to reduce the amount of gaseous particles present in order to reduce pressure. Hence, an increase in pressure will increase the amount of methanol.
		Temperature:
		Given that ΔH = negative, the forward reaction is exothermic. A decrease in temperature will cause the POE to shift right to favour the forward exothermic reaction to increase temperature. Hence, a decrease in temperature will increase the amount of methanol.
15	D	$[OH^{\#}] = K_w/[H^+] = 2.42 \times 10^{\#14} \div 10^{\#7.40} = 6.08 \times 10^{\#7} \text{ mol } dm^{\#3}$
16	A	A: Recall that H ⁺ does not contain any electrons so the total number of electrons in both $CO_3^{2#}$ and $HCO_3^{#}$ are the same. (32 electrons).
		B: The blood buffer system consists of H ₂ CO ₃ and HCO ₃ [#] .
		C: While $CO_3^{2#}$ can only exhibit basic property (as the conjugate base of $HCO_3^{#}$), $HCO_3^{#}$ can both exhibit acidic (as the conjugate acid of $CO_3^{2#}$) and basic property (as the conjugate base of H_2CO_3).
		D: They are a conjugate acid-base pair as they differ by 1 proton (H ⁺). A random combination of a weak acid and a weak base does not constitute a conjugate acid-base pair.
17	С	α increases as volume of water increases as the POE of HA(aq) = H ⁺ (aq) + A [#] (aq) shifts right (due to more species on the right hand side of equation are being diluted). α will taper near 1. pH increases as volume of water increases as the [H ⁺] decreases As it is an
		acidic solution, the pH will taper near pH 7.
		K_a does not vary with dilution. It is only affected by temperature.

18	А	Let the solubility of the salt be y mol dm ⁻³ .
		$Ca_{3}X_{2}(s) = 3Ca^{2+}(aq) + 2X^{3-}(aq)$
		Eqm []/ mol dm ⁻³ 3y 2y
		$K_{sp} = [Ca^{2+}]^3 [X^{3-}]^2$
		$S = (3y)^3(2y)^2$
		$S = 108y^5$
		$y = (\frac{S}{108})^{\frac{1}{5}}$
		$[Ca^{2+}(aq)] = 3y = 3(\frac{S}{108})^{\frac{1}{5}}$
19	D	Statement 1:
		Let concentrations of Cl^{-} and CrO_4^{2-} be x mol dm ⁻³ .
		$K_{sp}(AgCl) = [Ag^+][Cl^-]$
		$1.0 \times 10^{-20} = [Ag^+](x)$
		[Ag ⁺] required for precipitation = $\frac{1.0 \times 10^{-20}}{x}$ mol dm ⁻³
		$K_{sp}(Ag_2CrO_4) = [Ag^+]^2[CrO_4^{2-}]$
		$2.5 \times 10^{-22} = [Ag^+]^2(x)$
		[Ag ⁺] required for precipitation = $\sqrt{\frac{2.5 \times 10^{-22}}{x}}$ mol dm ⁻³
		[Ag ⁺] required for precipitation of AgC <i>l</i> is lower \Rightarrow AgC <i>l</i> should precipitate first. Hence, statement 1 is incorrect.
		Statement 2:
		Incorrect as K_{sp} is only affected by temperature.
		Statement 3:
		Correct as NH ₃ forms a soluble complex, $[Ag(NH_3)_2]^+$, resulting in a decrease in $[Ag^+]$. The positions of equilibrium of $AgCl = Ag^+ + Cl^-$ and $Ag_2CrO_4 = 2Ag^+$ + CrO_4^{2-} shift right, favouring the dissolution of both precipitates.



22	В	Statement 1 is incorrect. C3 is sp3 hybridised with tetrahedral arrangement. Statement 2 is correct. The p-orbital of C2 overlap sideway with both the p-orbital of oxygen atom and the π delocalised system of the benzene ring. Total delocalised π electrons = 6π electrons from benzene + 4π electrons from both C \exists O. Statement 3 is correct. Sp ² hybridised orbital is smaller than sp ³ hybridised orbitals due to higher s-character. Therefore, C1-C2 sigma bond involving sp ² -sp ² orbitals overlap is shorter and stronger than the C2-C3 sigma bond involving sp ² -sp ³ orbitals overlap.
23	D	Statement 1 is incorrect. Trigonal planar arrangement around the aldehyde carbon allows CN ⁻ to attack from either side of the plane, giving rise to a pair of enantiomeric products.
		Statement 2 is correct. Nucleophilic Addition: CH ₃ CH ₂ CHO + HCN \rightarrow CH ₃ CH ₂ CH(OH)CN
		Nucleophilic Substitution:
		CH ₃ CH ₂ CH(OH)C l + CN ⁻ → CH ₃ CH ₂ CH(OH)CN + C l ⁻
		Statement 3 is incorrect. Ketones are less reactive than aldehydes due to both steric and electronic reasons. Presence of 1 more electron donating alkyl group make the carbonyl carbon less electron deficient thus less attractive to nucleophiles, it also results in greater steric hindrance to nucleophilic attack.





29	А	Cu ²⁺ in wate	r: [Cu(H ₂ O) ₆]	²⁺ Blue co	lour (absorb yel	llow)	
		Cu ²⁺ in conc	entrated HC	: [Cu(C <i>l</i>) ₆]	^{4–} yellow colour	· (absorb purp	ole)
		Visible light	and energy:				
		Red	Orange	Yellow	Green	Blue	Purple
		Least energy					Most energy
		Energy gap	in blue comp	lex, [Cu(H	₂ O) ₆] ²⁺ , corresp	onds to yello	w visible light
	 Smaller energy gap between d-orbitals Weaker repulsion between ligands and d-orbitals 						
		Energy gap	in yellow con	nplex, [Cu([Cl) ₆] ^{4–} , corresp	onds to purpl	e visible light
	 Larger energy gap between d-orbitals Stronger repulsion between ligands and d-orbitals 						
30	D	From data b	ooklet:				
		Reduction p	rocesses:				
		$E^{(V^{3+}/V^{2+})} =$	–0.26 V				
		<i>E</i> [,] (VO ²⁺ /V ³⁺)	= +0.34 V				
		<i>E</i> [,] (VO ₂ ²⁺ /VO	²⁺) = +1.00 V	,			
		Oxidaiton pr	ocess:				
		<i>E</i> ,(Pb²⁺/Pb) ∺ most –ve <i>E</i> ,	= –0.13 V (Ne value. we wil	ote that sir onlv cons	nce Pb is addeo sider this proces	t in excess, a ss and ignore	the others)
		<i>E</i> ,(Mn ²⁺ /Mn)	= -1.18 V (N	ote that si	nce Mn is adde	d in excess, a	and this is the
		most –ve E	value, we wil	only cons	ider this proces	ss and ignore	the others)
		For addition	of excess Pb):			
		Oxidati proces and <i>E</i> value	on Red ss proce	uction ess and /alue	E [,] cell (<i>E</i> ,red – <i>E</i> ,ox)	Res	ult
		<i>E</i> ,(Pb ^{2+/} -0.13	Pb) <i>E</i> ,(VO) V +1	2 ²⁺ /VO ²⁺) .00 V	+1.13 V	Spontar VO ²⁺ fo	neous: prmed

	<i>E</i> ·(Pb ²⁺ /Pb) -0.13 V	<i>E</i> [,] (VO ²⁺ /V ³⁺) +0.34 V	+0.47 V	Spontaneous: V ³⁺ formed	
	<i>E</i> ·(Pb ²⁺ /Pb) −0.13 V	<i>E</i> ,(V ³⁺ /V ²⁺) −0.26 V	–0.13 V	Not spontaneous: V ²⁺ not formed	
He	ence, Final colo	ur is green (V ³⁺)			
For addition of excess Mn:					
	Oxidation process and <i>E[,]</i> value	Reduction process and <i>E</i> [,] value	E [,] cell (E,red − E,ox)	Result	
	<i>E</i> [,] (Mn²⁺/Mn) −1.18 V	<i>E</i> ₂ (VO ₂ ²⁺ /VO ²⁺) +1.00 V	+2.18 V	Spontaneous: VO ²⁺ formed	
	<i>E</i> _' (Mn ²⁺ /Mn) –1.18 V	<i>E</i> ,(VO ²⁺ /V ³⁺) +0.34 V	+1.52 V	Spontaneous: V ³⁺ formed	
	<i>E</i> [,] (Mn ²⁺ /Mn) −1.18 V	<i>E</i> ₂ (V ³⁺ /V ²⁺) −0.26 V	+0.92 V	spontaneous: V ²⁺ formed	
	L	l		l	