2024 Y6 Preliminary Examination H1 Chemistry 8873 Paper 1 Suggested Solutions

Answer Key

1	2	3	4	5		6	7	8	9	10
С	В	Α	D	В		D	В	С	С	В
11	12	13	14	15		16	17	18	19	20
Α	D	С	С	Α		В	D	Α	D	В
					-					
21	22	23	24	25		26	27	28	29	30
С	Α	Α	D	С		С	В	Α	D	D

1	С
	S: $1s^22s^22p^63s^23p^4$
	\Rightarrow options A and B are incorrect
	By Aufbau principle, the lower energy 3s orbital should be fully filled before occupying the higher energy 3p orbitals \Rightarrow option D is incorrect.
	Note: By Hund's rule, the 3p electrons will occupy the three degenerate 3p orbitals singly.

2	2	В					
		Give sulfu	Given the relative masses, V and W are isotopes of sulfur while X and Y are isotopes of iron.				
د	ĸ	1	Isotopes have (and electrons neutrons. Hence, Y (not)	the same num s) but differen f ²⁺) is isoelectro	ber of protons nt number of nic with X .		
,	1	2	isotope number of neutrons	$\frac{56}{26}$ Y 56 - 26 = 30	$^{32}_{16}$ V 32 - 16 = 16		
,	1	3	relative atomic = $\frac{(54)(31.4)+(56)(2)}{31.4+2}$	mass of iron in t = 54.1	his sample		
,	/	4	V ²⁺ and W ²⁺ ha V ²⁺ has a small Since angle of larger angle of o	ave the same clear relative mass deflection $\propto \frac{ch}{r}$	harge of 2+ but than W^{2+} $\frac{arge}{ass}$, V^{2+} has a N^{2+} .		

3	Α
	All p orbitals have the same dumbbell shape and two lobes per orbital.
	A 3p orbital is larger than a 2p orbital.
	A p_x orbital lies on the x-axis which is perpendicular to a p_z orbital which lies on the z-axis \Rightarrow different orientation of the orbitals in space

4 D $\Delta H_1 = 2^{nd} \text{ IE of Si} = +1580 \text{ kJ mol}^{-1}$ $\Delta H_2 = 2^{nd} \text{ IE of A}l = +1820 \text{ kJ mol}^{-1}$ $\Delta H_3 = \text{sum of } 1^{\text{st}} \& 2^{nd} \text{ IE of Si}$ $= 786 + 1580 = +2366 \text{ kJ mol}^{-1}$ order of decreasing enthalpy change: $\Delta H_3 > \Delta H_2 > \Delta H_1$

5	В			
×	A & D	Factors affecting atomic radius down the group are number of electron shells, shielding effect and nuclear charge \Rightarrow options A and D are incorrect.		
~	в	 B Increase in number of filled electron shells increases shielding effect and distance of valence electrons from the nucleus. This helps to explain the larger atomic radius of iodine. 		
×	с	Increase in number of protons increases nuclear charge and the attraction of the nucleus on the valence electrons. This does not explain why iodine has a larger atomic radius than chlorine.		

6	D
	magnitude of lattice energy $\propto \left \frac{q_+ \times q}{r_+ + r} \right $
	From the <i>Data Booklet</i> , Mg ²⁺ ; 0.065 nm, Na⁺; 0.095 nm, O ²⁻ ; 0.140 nm, F⁻; 0.136 nm.
	Magnitude of product of ionic charges: MgO > MgF = Na ₂ O > NaF
	The sum of ionic radii: MgO (0.205 nm) ≈ MgF (0.201 nm) < NaF (0.231 nm) ≈ Na₂O (0.235 nm)
	Hence MgO has the largest magnitude of lattice energy.

7	В			
	molecule	structure	shape	polarity
	NCl ₃		trigonal pyramidal	polar
	HCN	H−C≡N	linear	polar
	BeCl ₂	Cl-Be-Cl	linear	non-polar
	SOC12		trigonal pyramidal	polar

Hence, NCl_3 and $SOCl_2$ are polar and have the same shape.

8	С	
×	A	amount of Na ₂ SO ₄ = $0.08 \times 0.1 = 0.008$ mol Since one formula unit of Na ₂ SO ₄ contains three ions (two Na ⁺ and one SO ₄ ²⁻), total amount of ions 0.008 mol of Na ₂ SO ₄ = $0.008 \times 3 = 0.024$ mol
x	в	amount of Br ₂ (I) = 4 / (79.9 × 2) = 0.0250 mol
~	с	amount of H ₂ (g) = 500 / 24000 = 0.0208 mol
×	D	amount of $H_2O = 1 / 18 = 0.055555$ mol amount of atoms = $0.055555 \times 3 = 0.167$ mol

9	С	
		A mole of substance is the amount of that substance which contains as many elementary entities as there are carbon atoms in 12 grams of carbon-12.
		The correct statement should be:
×	Α	One mole of compound is the amount that contains the same number of compounds as there are atoms in 12.000 g of carbon-12.
		Note: a compound contains at least two elements and each formula unit contains at least two atoms
		Relative isotopic mass mass of 1 atom of the isotope
		$=\frac{1}{12}$ x mass of 1 atom of carbon-12
×	в	The correct statement should be:
		Relative isotopic mass of lithium-7
		$\frac{1}{12}$ x mass of 1 atom of carbon-12
		Relative atomic mass average mass of 1 atom
↓	С	$=\frac{1}{12}$ x mass of 1 atom of carbon-12

		Relative molecular mass mass of 1 molecule
		$=\frac{1}{12}$ x mass of 1 atom of carbon-12
×	D	The correct statement should be:
		Relative molecular mass of E
		$\frac{1}{12}$ x mass of 1 atom of carbon-12

10 B

amount of $Na_2S_2O_3$ needed to react with iodine liberated = 0.010×0.0225 = 2.25×10^{-4} mol

from the Data Booklet, $Cr_2O_7^{2-} \equiv 3I_2$ from the question, $3I_2 \equiv 6S_2O_3^{2-}$ Hence, $Cr_2O_7^{2-} \equiv 3I_2 \equiv 6S_2O_3^{2-}$

Moles of the Cr_2O_7^{2-} ions = 1/6 \times (2.25 \times 10^{-4}) = 3.75 \times 10^{-5} mol

[Cr₂O₇^{2–}] in 25 cm³ solution = $3.75 \times 10^{-5} / 0.025 =$ <u>0.00150 mol dm⁻³</u>

11	Α
	Solid X is Na ₂ O which is soluble in water to form the colourless alkaline solution of NaOH(aq).
	Note: X cannot be MgO because MgO is only slightly soluble in water so there will be white solid of MgO(s) remaining in the alkaline solution of $Mg(OH)_2(aq)$.
	Solid Y is insoluble in water and could be either $Al_2O_3(s)$ or $SiO_2(s)$. Since Y is soluble in dilute NaOH(aq), Y is $Al_2O_3(s)$ which is amphoteric.
	Solid X (Na ₂ O) is soluble in HC/(aq) as it readily dissolves in water.
	Solid Y (Al_2O_3) undergoes acid-base reaction with $HCl(aq)$ to form a colourless solution:
	$Al_2O_3(s) + 6HCl(aq) \rightarrow 2AlCl_3(aq) + 3H_2O(l)$

12	D	
×	А	first ionisation energy: Mg (736 kJ mol⁻¹) < S (1000 kJ mol⁻¹) < P (1060 kJ mol⁻¹)
×	в	electronegativity: increases across the Period so $Al < Si < Cl$
×	с	melting point: A <i>l</i> > Na > P
~	D	electrical conductivity: S (non-conductor) < Si (semi-conductor) < Na (conductor)

13	С
	A/C/3(s) undergoes partial hydrolysis in water:
	$A/Cl_3(s) + 6H_2O(l) \rightarrow [A/(H_2O)_6]^{3+}(ag) + 3Cl^{-}(ag)$
	$[A_{l}(H_{2}O)_{6}]^{3+}(aq) + H_{2}O(I)$
	$[A_1(H_2O)_5(OH)]^{2+}(aq) + H_3O^+(aq)$ (pH = 3)
	PCl ₅ (s) undergoes complete hydrolysis in water:
	$PCl_5(s) + 4H_2O(l) \rightarrow H_3PO_4(aq) + 5HCl(aq) (pH = 2)$
	Hence option D is incorrect.
	Acidia actuations are formed as antion A is incorrect
	Actaic solutions are formed so option A is incorrect.
	is incorrect
	is incorrect.
	Note: acidic fumes of HCl(g) are observed when the
	chlorides react with <i>limited cold</i> water:
	$PCl_5(s) + H_2O(I) \rightarrow POCl_3(I) + 2HCl(g)$
	$AlCl_3(s) + 3H_2O(l) \rightarrow Al(OH)_3(s) + 3HCl(g)$
	NaCl dissolves in water and no hydrolysis occurs so
	pH of solution formed = 7 .
	$NaCl(s) \rightarrow Na^{+}(aq) + Cl^{-}(aq)$
14	С
	Cl ₂ is a stronger oxidising agent than Br ₂ so Cl ₂ will

Cl₂ is a stronger oxidising agent than Br₂ so Cl₂ will oxidise Br⁻ to Br₂ while itself is reduced to Cl⁻. $Cl_2(aq) + 2Br^-(aq) \rightarrow Br_2(aq) + 2Cl^-(aq)$ The colourless KBr solution turns orange due to the mixture of orange Br₂(aq) formed and remaining pale yellow $Cl_2(aq)$ so options A & D are incorrect.

On addition of AgNO₃(aq), white ppt of AgC*l* is formed. There is no remaining Br⁻(aq) ions to form cream ppt of AgBr. Ag⁺(aq) + $Cl^{-}(aq) \rightarrow AgCl(s)$

 $\begin{array}{c|c} \textbf{15} & \textbf{A} \\ \\ \hline \\ & \text{The reaction took 10 s for } [N_2O_5] \text{ to decrease from} \\ & 0.040 \text{ to } 0.020 \text{ mol } dm^{-3} \text{, and another 10 s for } [N_2O_5] \\ & \text{to further decrease from } 0.020 \text{ to } 0.010 \text{ mol } dm^{-3} \text{.} \end{array}$

Hence, the half-life of the reaction is constant at 10 s and the order of reaction with respect to N_2O_5 is 1.

It follows that rate = $k[N_2O_5]$ and the units of k is s⁻¹.

16	В
	Comparing experiments 1 & 2, When initial $[BrO_3^-] \times 2$ while keeping initial $[Br^-]$ and $[H^+]$ constant, initial rate $\times 2$. Hence order of reaction with respect to BrO_3^- is 1 \Rightarrow options A & D are incorrect.
	Comparing experiments 1 & 3, When initial $[Br^-] \times 2$ and initial $[H^+] \times 3$ while keeping initial $[BrO_3^-]$ constant, initial rate \times 18.
	The factor of 18 can be attributed to $2^1 \times 3^2$ where the order of reaction with respect to Br ⁻ and H ⁺ are 1 and 2 respectively.

17	D	
~	1	HNO_3 oxidises P_4 to H_3PO_4 while itself is reduced to NO_2 .
		Oxidation half-equation: 16H ₂ O + P ₄ \rightarrow 4H ₃ PO ₄ + 20H ⁺ + 20e ⁻ (×1)
~	2	Reduction half-equation: H⁺ + e⁻ + HNO ₃ → NO ₂ + H₂O (×20)
		Overall redox equation: P ₄ + 20HNO ₃ \rightarrow 4H ₃ PO ₄ + 4H ₂ O + 20NO ₂
~	3	The oxidation state of N in HNO ₃ is +5 and the oxidation state of P in H_3PO_4 is +5.

18	Α	
~	1	By Hess' law, $\Delta H_1 + \Delta H_2 = \Delta H_3 + \Delta H_4$
~	2	$\Delta H_2 = 5 \times BE(Cl - Cl)$ = 5 × 244 = 1220 kJ mol ⁻¹
~	3	2 mol of $PCI_5(s)$ are formed from the constituent elements in their standard states.

19	D	
×	A	$\begin{split} & \Delta H^{\Theta}_{\text{formation}} \text{ of } N_2(g) = \Delta H^{\Theta}_{\text{formation}} \text{ of } H_2(g) = 0 \text{ as} \\ & \text{they are elements in their standard states.} \\ & \text{Hence, } 2 \times \Delta H^{\Theta}_{\text{formation}} \text{ of } NH_3(g) - 0 = -92 \\ & \Delta H^{\Theta}_{\text{formation}} \text{ of } NH_3(g) = -46 \text{ kJ mol}^{-1} \end{split}$
×	в	The magnitude of the enthalpy change remains the same while its sign is reversed for the reverse reaction.
×	с	BE(N=N) + 3BE(H-H) - 6BE(N-H) = -92 944 + 3(436) - 6BE(N-H) = -92 6BE(N-H) = 2344 BE(N-H) = +390.66 = +391 kJ mol ⁻¹
✓	D	All the above conclusions can be drawn.

20 B Pressure of chlorine gas

•	starts from zero as only $PCl_5(s)$ was present in the vessel initially \Rightarrow option A is incorrect.
•	increases with time as $Cl_2(g)$ is formed from the dissociation of $PCl_5(s)$ until a constant value at equilibrium where the amount of $Cl_2(g)$ remains unchanged \Rightarrow option C is incorrect.
•	rate of the forward reaction to form $Cl_2(g)$ decreases with time until it is a constant at equilibrium \Rightarrow option D is incorrect (rate increases initially then decreases until it is a constant).

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21	C		
	$pH = -log_{10}[H^+] = 3.2$		
	$[H^+] = 10^{-3.2} = 6.3095 \times 10^{-4} \text{ mol dm}^{-3}$		
	moles of H ⁺ in 4 dm ³ = 0.0025238 mol		
	initial moles of HX in 4 dm ³		
	$= 0.0025238 \times 100 = 0.252 \text{ mol}$		
22	Α		
	As pH of the blood decreases, [H ⁺] in the blood		
	increases.		

1	1	By Le Chatelier's principle, the position of equilibrium (2) will shift to the left to decrease the [H ⁺]. This increases the [H ₂ CO ₃] which will in turn shift the position of equilibrium (1) to the left to decrease the [H ₂ CO ₃]. $CO_2 + H_2O \rightleftharpoons H_2CO_3 (1)$ $H_2CO_3 \rightleftharpoons HCO_3^- + H^+ (2)$
~	2	In the backward reaction of equilibrium (2), HCO_3^- accepts the H ⁺ to form H_2CO_3 , acting as a Brønsted-Lowry base.
×	3	As the position of equilibrium (1) shifts to the left, the $[CO_2]$ in the blood increases.





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26 C

Solving tip: Note that the left hand side of \mathbf{R} bears a threecarbon long chain and that right hand side of \mathbf{R} carries a four-carbon chain. This indicates that the hydrolysis happens at the ether oxygen. Using the molecular formula of \mathbf{T} , one can deduce that it is a saturated alcohol.





T undergoes elimination of water (dehydration) to form three different alkenes.



Molecular mass of ester formed $= (10 \times 12.0) + (12 \times 1.0) + (4 \times 16.0)$ = 196.0 g mol⁻¹

28	Α	
	P :	
*	Α	In its semi-crystalline form, the crystalline regions of P are tightly packed and well- organised, contributing to the material's rigidity and strength. The ordered packing in the crystalline regions of P enhances intermolecular forces, i.e. permanent dipole- permanent dipole forces and instantaneous dipole-induced dipole interactions.
×	в	While the ester linkages in P can form hydrogen bonds with water, P contains non-polar benzene ring and hydrocarbon chain that interfere with its formation of hydrogen bonds with water.
×	с	P does not have unsaturated side-groups to allow each polymeric chain of P to form strong covalent cross-links with another chain.
×	D	A container made of P cannot be used to store strongly alkaline cleaning solutions as the ester linkages will undergo alkaline hydrolysis and the material will disintegrate.



30	D	
×	1	Graphene is a single layer of carbon atoms arranged in a hexagonal lattice, not multiple layers.
~	2	The high electrical conductivity of graphene is due to the presence of delocalised electrons that can move freely across the lattice.
×	3	The exceptional tensile strength of graphene is due to the strong covalent bonds between the carbon atoms within the layer.