2025 DHS Preliminary Examination
H1 Chemistry 8873 Paper 1
Suggested Solutions

Answer Key

1	2	3	4	5	6	7	8	9	10
D	**D**	**B**	**B**	**D**	**A**	**C**	**D**	**C**	**B**

11	12	13	14	15	16	17	18	19	20
D	**B**	**A**	**A**	**A**	**B**	**C**	**A**	**C**	**C**

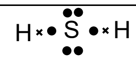
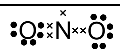
21	22	23	24	25	26	27	28	29	30
B	**D**	**A**	**B**	**A**	**D**	**C**	**D**	**B**	**B**

1	**D**
	Since the gas is **diatomic**, the number of molecules of this gas in the 5 g sample $= (3.76 \times 10^{22}) \div 2 = 1.88 \times 10^{22}$ Therefore, the number of moles of this gas $= (1.88 \times 10^{22}) \div (6.02 \times 10^{23}) = 0.03123$ Thus, M_r of the gas $= 5 \div (0.03123) = 160$

2	**D**	
×	**A**	Since both particles have a positive angle of deflection, they are deflected in the same direction towards the same plate. Similar to $^{4}He^{2+}$, **X** must be positively charged.
×	**B**	The beam of positively charged particles **X** travels in a curved path towards the negatively charged plate.
×	**C**	Charge to mass ratio of $^{12}C^{+} = +\frac{1}{12}$ Charge to mass ratio of $^{4}He^{2+} = +\frac{2}{4} = +\frac{1}{2}$ Since angle of deflection is proportional to charge to mass ratio, the angle of deflection of $^{12}C^{+}$ is expected to be $\frac{1}{6}(1) = +0.17°$
✓	**D**	None of the above options are correct.

3	**B**	
×	**A**	Element with electronic configuration of $1s^2 2s^2 2p^6 3s^2 3p^1$ is Al. Al can lose three electrons to form Al^{3+}.
✓	**B**	Element with electronic configuration of $1s^2 2s^2 2p^6 3s^2 3p^3$ is P. P can gain three electrons to form P^{3-}.
×	**C**	Element with electronic configuration of $1s^2 2s^2 2p^6 3s^2 3p^6 3d^1 4s^2$ is Sc. Sc can lose three electrons to form Sc^{3+}.
×	**D**	Element with electronic configuration of $1s^2 2s^2 2p^6 3s^2 3p^6 3d^7 4s^2$ is Co. Co tends to lose electrons to form simple ions such as Co^{2+} or Co^{3+}.

4	**B**
	1. Determine the number of neutrons in Sr (find proton number of Sr using *Data Booklet*.) ⇒ 84 – 38 = 46 2. Find number of electrons present in Sr^{2+} (using proton number of Sr given in Data Booklet.) ⇒ 38 – 2 = 36 ⇒ **W** has 36 electrons 3. Find number of protons present in **W** **W**: 36 protons 4. Calculate the nucleon number of **W** **W**: 36 + 46 = 82

5	**D**	
×	**A**	Electronic configuration of Cr atom is $1s^2 2s^2 2p^6 3s^2 3p^6 3d^5 4s^1$. There are six unpaired electrons.
×	**B**	Electronic configuration of Cu^{+} ion is $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10}$. There are no unpaired electrons.
×	**C**	 There are no unpaired electrons.
✓	**D**	 There is one unpaired electron on the N atom in the NO_2 molecule.

6	**A** (1 and 2 only)	
✓	**1**	C=O and C=S are polar covalent bonds due to the difference in electronegativity between the atoms.
✓	**2**	The dipole moments of the polar bonds are equal and opposite in O=C=O and S=C=S molecules so they cancel out and the molecules are non-polar. There exists only instantaneous dipole–induced dipole (id–id) interactions between these non–polar molecules. As O is more electronegative than S, C=O bond is more polar than C=S bond and there is a net dipole moment in O=C=S. Hence, COS molecule is polar and it has both id–id and permanent dipole–permanent dipole interactions between molecules.
×	**3**	O=C=S has a smaller, less polarisable electron cloud than S=C=S. Hence, O=C=S has weaker id-id interactions between molecules than S=C=S.

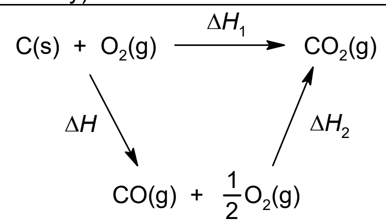
7	**C**	
×	**A**	Ice has a simple molecular structure with hydrogen bonds between water molecules. There are covalent bonds between atoms in the water molecules.
×	**B**	Iodine, I_2, has a simple molecular structure and is a non-polar molecule. There exists instantaneous dipole–induced dipole (id–id) interactions between molecules and covalent bond between iodine atoms in a molecule.
✓	**C**	Sodium nitrate, $NaNO_3$, has a giant ionic structure with ionic bonds between oppositely charged Na^{+} and NO_3^{-} ions. Within the NO_3^{-} ion, there are covalent bonds between N and O atoms.
×	**D**	Manganese has a giant metallic structure with metallic bonds between the positively charged metal cations and sea of delocalised electrons.

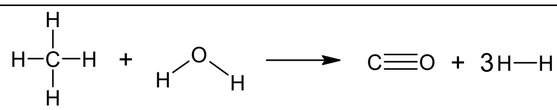
8	**D**	
×	**A**	Both $CH_3CH_2CH_2NH_2$ and $(CH_3)_3N$ are polar molecules.
×	**B**	Both $CH_3CH_2CH_2NH_2$ and $(CH_3)_3N$ are chain isomers. Hence they have the same number of electrons.
×	**C**	$CH_3CH_2CH_2NH_2$ is a straight chain molecule while $(CH_3)_3N$ is a branched chain molecule. Hence $CH_3CH_2CH_2NH_2$ has a greater surface area of interaction. However, this explanation is only used to explain the difference in boiling points when the predominant intermolecular forces of interaction for both molecules is id-id interactions.
✓	**D**	The predominant forces of attraction for $CH_3CH_2CH_2NH_2$ is intermolecular hydrogen bonding while that for $(CH_3)_3N$ is permanent dipole-permanent dipole interactions. Hence more energy is required to overcome the hydrogen bonding between $CH_3CH_2CH_2NH_2$.

9	**C**
	Volume of gas before burning = 60 cm^3 Volume of gas used = 10 + 30 = 40 cm^3 Volume of gas produced after burning = 30 cm^3 Volume of gas remaining = 60 – 40 + 30 = 50 cm^3 CO_2 and SO_2 are both acidic gases hence both will react with aq NaOH. Hence vol of gas after adding aq NaOH = 50 – 30 = 20 cm^3

10	**B**	
	Oxidation half-equation: $Fe^{2+} \rightarrow Fe^{3+} + e^-$ $Fe^{2+} \equiv e^-$ amount of electrons transferred $= \frac{30.0}{1000} \times 0.200 = 0.00600$ mol $\frac{\text{amount of electrons}}{\text{amount of nitrate ions}} = \frac{0.00600}{0.00200} = \frac{3}{1}$ The oxidation state of nitrogen decreases by 3 from +5 in NO_3^- to +2.	
×	**A**	The oxidation state of N in N_2 is 0.
✓	**B**	The oxidation state of N in NO is +2.
×	**C**	The oxidation state of N in NO_2^- is +3.
×	**D**	The oxidation state of N in NO_2 is +4.

11	**D**
	Reduction half-equation (from *Data Booklet*): $Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow 2Cr^{3+} + 7H_2O$ Combine both half-equations by balancing the number of electrons transferred: ($Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow 2Cr^{3+} + 7H_2O$) x 2 ($CH_3CH_2OH + H_2O \rightarrow CH_3COOH + 4H^+ + 4e^-$) x 3 Overall balanced redox equation: $2Cr_2O_7^{2-} + 16H^+ + 3CH_3CH_2OH$ $\rightarrow 4Cr^{3+} + 11H_2O + 3CH_3COOH$
	$2Cr_2O_7^{2-} \equiv 3CH_3CH_2OH$ 1 mol of $Cr_2O_7^{2-}$ reacts with 1.5 mol of CH_3CH_2OH

12	**B** (2 and 3 only)
	 ΔH_1 = the standard enthalpy change of formation of carbon dioxide ΔH_2 = the standard enthalpy change of combustion of carbon monoxide By Hess' Law, $\Delta H = \Delta H_1 - \Delta H_2$ so values of ΔH_1 and ΔH_2 are needed to calculate ΔH.

13	**A**
	 ΔH = [4(410) + 2(460)] – [1077 + 3(436)] = **<u>+175 kJ mol⁻¹</u>**

14	**A**	
✓	**A**	1 mol of PCl_5(s) is formed from its constituent elements, P(s) and Cl_2(g).
×	**B**	The correct equation is $H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$
×	**C**	The correct equation is $2Na^+(g) + O^{2-}(g) \rightarrow Na_2O(s)$
×	**D**	The correct equation is $Cl_2(g) \rightarrow 2Cl(g)$

15	**A**
	Removal of aspirin $x\ (100\%) \xrightarrow{t_{1/2}} \frac{x}{2} (50\%) \xrightarrow{t_{1/2}} \frac{x}{4}\ (25\%) \xrightarrow{t_{1/2}} \frac{x}{8} (12.5\%)$ $3\ t_{1/2}$ = 6 h $t_{1/2}$ = 2 h = 120 min

16	**B**
	rate = $k[BrO_3^-][Br^-][H^+]^2$ units of rate = units of k x (units of concentration)^4 units of k = units of rate ÷ (units of concentration)^4 $= \frac{mol\ dm^{-3}\ s^{-1}}{(mol\ dm^{-3})^4}$ $= \frac{s^{-1}}{(mol\ dm^{-3})^3}$ $= mol^{-3}\ dm^9\ s^{-1}$

17	C	
✗	A	Addition of catalyst does not shift the position of equilibrium as it increases the rate of both forward and backward reaction to the same extent. K_c remains unchanged as it is temperature dependent.
✗	B	Addition of ammonia gas increases its concentration. The position of equilibrium shifts left to remove the added ammonia gas. K_c remains unchanged as it is temperature dependent.
✓	C	Decrease in temperature will shift the position of equilibrium to the right to favour exothermic reaction to release heat. Hence, there is an increase in [products] and decrease in [reactants]. K_c will increase.
✗	D	Increasing the pressure of the vessel causes the position of equilibrium to shift right to decrease the number of gaseous particles. K_c remains unchanged as it is temperature dependent.

18 A

Completing the ICE table in amounts (in mol):

	$2\,SO_2$	+	O_2	⇌	SO_3
I	2		1		0
C	$-(2-x)$		$-\frac{1}{2}(2-x)$		$+(2-x)$
E	x		$x/2$		$(2-x)$

19	C	
✗	A	This is a redox reaction, not an acid-base reaction.
✗	B	H_2O behaves as Brønsted-Lowry acid, donating a proton to oxide, O^{2-}, forming OH^-.
✓	C	A Brønsted-Lowry base accepts a H^+ in an acid-base reaction. Option C shows CH_3NH_2 accepting H^+ from HCl to form a salt $CH_3NH_3^+Cl^-$.
✗	D	H_2SO_4 is a Brønsted-Lowry acid. It is a H^+ donor.

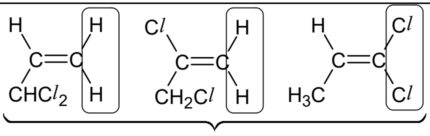
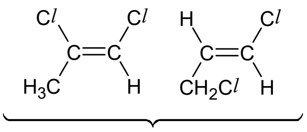
20	C	
✗	A	Since $H_2SO_4 \equiv 2H^+$ $[H^+] = 2 \times 0.1$ mol dm^{-3} = 0.2 mol dm^{-3} initial pH = $-\lg[H^+] = -\lg(0.2)$ = 0.699
✗	B	Equivalence point of a strong acid – weak base titration pH < 7.
✓	C	When $2x$ cm^3 of NH_3(aq) is added, NH_3(aq) is added in excess. Thus, all H_2SO_4 has been reacted to form NH_4^+ salt. In the solution, there is excess weak base, NH_3(aq), and salt of weak base, NH_4^+, thus an alkaline buffer is formed.
✗	D	When x cm^3 of NH_3 is added, complete neutralisation occurs. $H_2SO_4 \equiv 2NH_3$ amt of NH_3 = amt of H^+ = $0.1 \times 2 \times \frac{25}{1000}$ = 0.00500 mol vol of NH_3 = $0.00500 \times \frac{1000}{0.1}$ = 50 cm^3

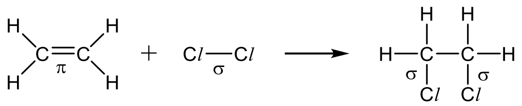
21	B	
✗	A	Graph shows the trend of melting point of Period 3 elements.
✓	B	Graph shows the trend of electrical conductivity of Period 3 elements.
✗	C	Graph shows the trend of ionic radii of Period 3 elements.
✗	D	Graph shows the trend of 1st IE of Period 3 elements.

22	D
	K is phosphorus as the P^{3-} has the largest ionic radii amongst the Period 3 ions. The cations are smaller has they have one less shell of electrons compared to the anions. Amongst the isoelectronic anions, P^{3-} has the lowest nuclear charge hence the weakest electrostatic forces of attraction for its valence electrons. **L** is silicon. Large amount of energy is required to break the strong and extensive covalent bonds between Si atoms in the 3-dimensional network structure. **M** is magnesium. It has the second highest number of delocalised electrons in its solid lattice, hence the second highest electrical conductivity behind aluminium. In order of increasing atomic number: **M** (magnesium) < **L** (silicon) < **K** (phosphorus)

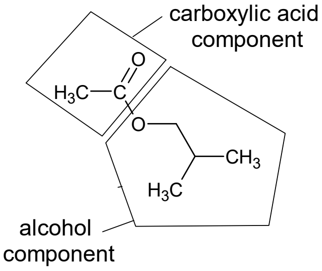
23	**A** (2 and 3 only)	
✗	1	Group 1 metals react vigorously with water, producing hydrogen gas (NOT oxygen) and a metal hydroxide. M(s) + H_2O(l) → MOH(aq) + ½ H_2(g)
✓	2	The ease of losing electrons i.e. oxidised increase down Group 1 due to increasingly weaker nuclear attraction between the valence electron and the nucleus as size increases down the Group.
✓	3	Electronegativity decreases down the group. Hence sodium is more electronegative than caesium.
✗	4	Group 1 elements can conduct electricity in both solid and liquid state due to the presence of delocalised electrons.

24	B	
✗	A	Boiling and melting point increases down the group. Iodine is already a solid at room temperature, hence astatine, with a higher melting point, would also exist as a solid at room temperature.
✓	B	Oxidising power decreases down Group 17, so iodine should be a stronger oxidising agent than astatine.
✗	C	Due to astatine's larger atomic radius, At-At will have a longer bond length and hence weaker bond strength compared to I_2 and hence At_2 would dissociate more readily than I_2.
✗	D	Down the Group, ease of thermal decomposition of the Group 17 hydrides increases as the strength of H-X bond decreases. ⇒ thermal stability: HF > HCl > HBr > HI

25	A
	 do not exhibit cis-trans isomerism because of two identical atoms on one carbon of the C=C bond  exhibit cis-trans isomerism

26	D
	

27	C	
×	A	Propanone (CH_3COCH_3) does not react with acidified $K_2Cr_2O_7$.
×	B	Propan-2-ol ($CH_3CH(OH)CH_3$, a secondary alcohol) undergoes oxidation with acidified $K_2Cr_2O_7$ to form propanone (CH_3COCH_3, a ketone). Ketone does not undergo elimination reaction to form an alkene.
✓	C	2-chloropropane ($CH_3CHClCH_3$, a chloroalkane) undergoes substitution reaction with NaOH(aq) to form propan-2-ol ($CH_3CH(OH)CH_3$, an alcohol). Propan-2-ol undergoes elimination reaction to form propene (an alkene).
×	D	Propanoic acid (CH_3CH_2COOH) undergoes neutralisation with NaOH(aq) to form salt (sodium propanoate, $CH_3CH_2COO^-Na^+$). Sodium propanoate does not undergo elimination reaction to form an alkene.

28	D
	2-methylpropyl ethanoate has the following structure:  Hence the carboxylic acid and alcohol needed to make 2-methylpropyl ethanoate are CH_3COOH and $(CH_3)_2CHCH_2OH$ respectively.

29	B
	soft contact lenses – PVA The polymer can have a higher water content as it can form hydrogen bonds with water molecules due to the presence of –OH groups. wrinkle-free shirt – polyester Polyesters form less extensive hydrogen bonds with water molecules. Thus, they do not absorb water well. There is minimal disruption to the arrangement of the polymer chain and hence, polyesters are wrinkle-resistant. microwavable food packaging – poly(propene) Inert and does not contain functional groups such as ester or amide that will undergo hydrolysis with acid or base in food. poly(propene) also has a high melting point. bottles for alkaline cleaning solutions – HDPE Inert and does not contain functional groups that will react with alkali. PET is not suitable as it is a polyester and it will be hydrolysed in alkaline solution.

30	**B** (2 and 3 only)	
×	1	Nanoparticles can be found naturally or manufactured synthetically but the ones used for heterogeneous catalysis (Pt, Pd in catalytic convertors) are more likely manufactured.
✓	2	Due to the large surface area to volume ratio of nanoparticles, they can be used in smaller quantities hence cheaper as less particles are wasted buried within the catalyst's surface.
✓	3	Refer to Option 2
×	4	There are several risks (health and environment) associated with the use of nanoparticles so they have to be used with caution.