# 2025 Y6 H2 Chemistry Preliminary Exams Paper 1 – Suggested Solutions

| Question | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Answer | A | D | C | C | B | D | C | B | B | A | D | B | A | A | C |

| Question | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Answer | C | B | C | B | D | B | D | B | C | A | C | D | A | D | A |

## MCQ worked solutions

**Q1 (Ans: A)**

The $^{37}Cl^{+}$ ion has 37 nucleons which comprise 17 protons and 20 neutrons.
It has one positive charge (having lost one electron) and hence it has a total of 16 electrons.

**Q2 (Ans: D)**

angle of deflection $\propto \left|\frac{q}{m}\right|$
For $^{17}O^{+}$, $\left|\frac{q}{m}\right| = \frac{1}{17}$ (= 0.0588)
For $[^{16}O^{18}O]^{2-}$, $\left|\frac{q}{m}\right| = \frac{2}{(16+18)} = \frac{1}{17}$ (= 0.0588)
Hence $[^{16}O^{18}O]^{2-}$ will be deflected to the same extent as $^{17}O^{+}$.
Option 1 is incorrect.

Option 2 is correct since positively charged species will deflect in an opposite direction to negatively charged species.

Each beam of charged particles will travel in a curved path, not a straight path.
Option 3 is incorrect.

**Q3 (Ans: C)**

The cis-isomer (Q) has a higher boiling point as it has a net dipole moment and has permanent dipole-permanent-dipole interactions, whereas the trans-isomer (P) is non-polar.

R has instantaneous dipole-induced dipole interactions, as well as the smallest electron cloud and hence has the weakest interactions amongst the three. Thus, it has the lowest boiling point.

Correct order of increasing boiling point: R < P < Q.

**Q4 (Ans: C)**

$BeF_2$ acts as a Lewis acid (as $NH_3$ donates its lone pair to Be to form $H_3N{\rightarrow}BeF_2$).
A is incorrect.

It is tetrahedral around the N atom in $BeF_2 \bullet NH_3$, hence the molecule is not planar.
B is incorrect.

In $BeF_4^{2-}$, two $F^-$ ions form one co-ordinate bond each with $BeF_2$.
C is correct.

It is possible for the lone pair on F to form a hydrogen bond with the H in $H_2O$.
D is incorrect.

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**Q5 (Ans: B)**

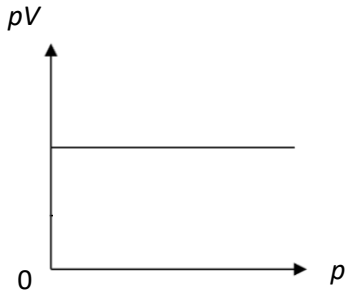
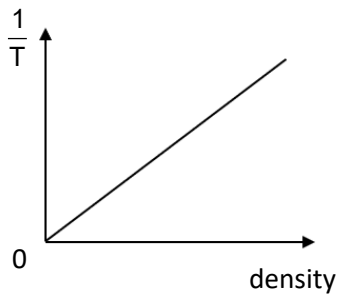
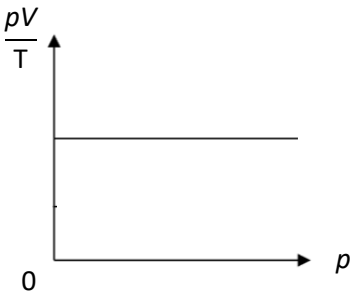
$pV = nRT$

$p = \frac{1}{V}(nRT)$

Since n, R and T are constants,

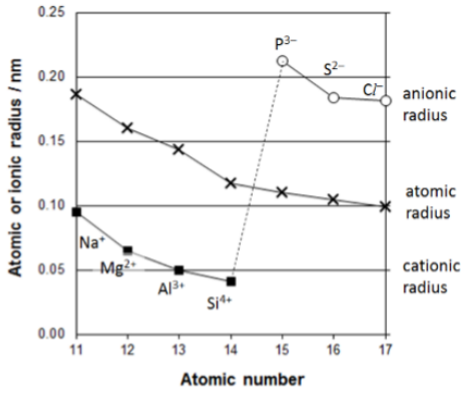
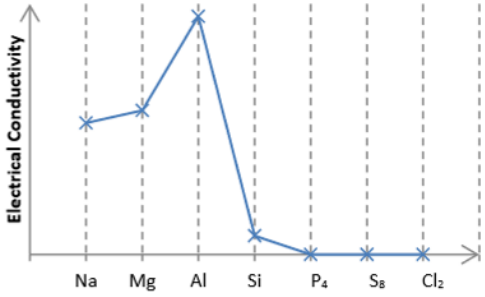
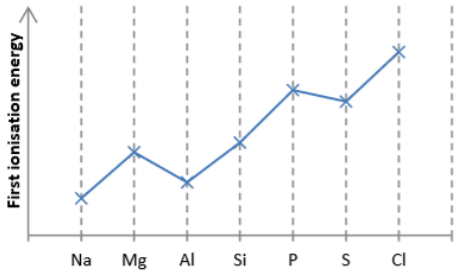
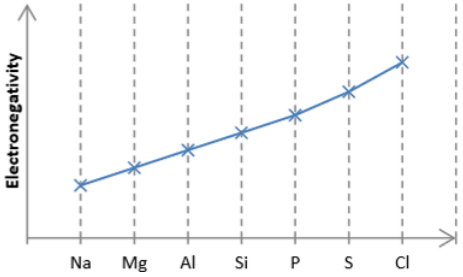
$p = \frac{1}{V}(k)$

Hence graph is *y = kx (straight line that passes through origin)*

| Option A | Option C | Option D |
|---|---|---|
| $pV = nRT$<br>Since n, R and T are constants,<br>$pV$ = constant at a particular T<br>  <br> | $pV = nRT$<br>$p = \frac{mass}{MV}RT$<br>$= density(\frac{RT}{M})$<br>$\frac{1}{T} = density(\frac{R}{Mp})$<br>Since R, M and $p$ are constants,<br>$\frac{1}{T} = density(k)$<br>  <br> | $pV = nRT$<br>$\frac{pV}{T} = nR$<br>Since n and R are constants,<br>$\frac{pV}{T}$ = constant at a particular n<br>  <br> |

**Q6 (Ans: D)**

| element | identity |
|---|---|
| X | Si |
| Y | Na |
| Z | P |

| | | |
|---|---|---|
| ✗ | **A** | Y (Na) has a smaller atomic radius than Z (P)<br>  |
| ✗ | **B** | Y (Na) has a lower electrical conductivity than X (Si)<br>  |
| ✗ | **C** | X (Si) has a higher first ionisation energy than Z (P)<br>  |
| ✓ | **D** | X (Si) has a higher electronegativity value than Y (Na)<br>  |

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**Q7 (Ans: C)**

| | |
|---|---|
| **A** | $E^{\ominus}$ value becomes more negative down the Group.<br>$M^{2+}(aq) + 2e \rightleftharpoons M(s)$ $E^{\ominus}$<br><br>The tendency of backward reaction occurring increases, hence reducing power of metal increases. |
| **B** | The reactivity of Group 2 elements increases down the group as the ease of Group 2 elements losing electrons increases down the group. |
| **C** | Cationic radius increases down the Group, resulting in a lower charge density and weaker polarising power of the cations. Consequently, there is decreasing extent of distortion of the electron cloud of the $CO_3^{2-}$ anion and hence decreasing extent of weakening of covalent bonds within the $CO_3^{2-}$ anion. More heat energy is required to break the covalent bonds within the $CO_3^{2-}$ anion, causing the decomposition temperature to increase.<br>Hence, the thermal stability of the Group 2 carbonates increases. |
| **D** | As cationic radius increases down the Group,<br>$\left\lvert \Delta H_{hyd}^{\ominus}[M^+(g)] \right\rvert \propto \left\lvert \frac{q_+}{r_+} \right\rvert$<br>the magnitude of the enthalpy of hydration of the metal ion decreases. |

**Q8 (Ans: B)**

Let the nitrogen-containing compound be X. Since the mole ratio of $NO_2$ to $HNO_3$ is 3:2, the remaining N atom is in X. Hence, the redox equation involving only the N compounds is:

$3\ NO_2 \rightarrow X + 2\ HNO_3$

2 moles of $NO_2$ (where N has an oxidation state of +4) is oxidised to 2 moles of $HNO_3$ (where N has an oxidation state of +5) by the **loss of 2e$^-$**.

Therefore, the remaining 1 mole of $NO_2$ **gains 2e$^-$** when it is reduced to 1 mole of X. Thus, the oxidation of N in X is +2. Hence, X is NO.

Alternatively, the redox equation can be balanced by stoichiometry to deduce the identity of X.

**Q9 (Ans: B)**

$$A_r \text{ of Cr} = \frac{(4.3)(50) + (83.8)(52) + (9.5)(53) + (2.4)(54)}{(4.3 + 83.8 + 9.5 + 2.4)} = 52.06 = 52.1$$

Note that the sum of the relative abundances may not always add up 100. Hence, it's necessary to divide the numerator by the sum of the relative abundances given.

**Q10 (Ans: A)**

| | | |
|---|---|---|
| ✓ | 1 | Sublimation requires energy to overcome the attractive forces holding the particles together in a solid state to change into a gaseous state. |
| ✗ | 2 | The combustion of all fuels is always exothermic. |
| ✗ | 3 | The formation of ion-dipole interactions releases energy, making the process exothermic. |

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**Q11 (Ans: D)**

Theoretical lattice energy can be calculated using

$$|\text{lattice energy}| \propto \left|\frac{q_+ q_-}{r_+ + r_-}\right|$$

which assumes a 100% ionic nature. The discrepancy between the experimental and theoretical lattice energies shows the presence of covalent character in the bonding in the silver halides, arises due to substantial polarisation of the anion by the cation. Since the anionic radius increases down the Group, the polarisability of the anion increases, causing a greater degree of covalency and hence greater deviation of the experimental from the theoretical value.

**Q12 (Ans: B)**

A possible method to solving this question without an energy cycle is to use the algebraic method (refer to section 4.7 of your lecture notes for Energetics Part 1).

| | enthalpy change / kJ $mol^{-1}$ |
|---|---|
| $\cancel{Ba(s)} + O_2(g) \longrightarrow \cancel{BaO_2(s)}$ | s |
| $\cancel{BaO_2(s)} \longrightarrow \cancel{Ba^{2+}(g)} + O_2^{2-}(g)$ | −q |
| $\cancel{Ba^{2+}(g)} + 2e^- \longrightarrow \cancel{Ba(g)}$ | −p |
| $\cancel{Ba(g)} \longrightarrow \cancel{Ba(s)}$ | −r |
| | |
| $O_2(g) + 2e^- \longrightarrow O_2^{2-}(g)$ | s – q – p – r |

**Q13 (Ans: A)**

Statement A is correct. Adding a catalyst to increase the rate of reaction increases the value of the rate constant (by decreasing the activation energy).

Statement B is incorrect. In autocatalytic reactions, the concentration of the catalyst increases as the products are formed, thus increasing the rate of reaction initially. However, as the concentration of the reactants decrease, the rate of reaction also decreases.

Statement C is incorrect. Heterogeneous catalysts are in a different phase from the reactant molecules.

Statement D is incorrect. In enzyme-catalysed reactions, increasing the concentration of the substrate increases the rate of the reaction until all the active sites are saturated, after which, the concentration of the substrate has no effect on the rate of the reaction.

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**Q14 (Ans: A)**

At constant temperature, pressure is directly proportional to concentration,
since pV=nRT => $\frac{P}{RT} = \frac{n}{V}$ => $p \propto \frac{n}{V}$ .

At very low pressures of A, the $k_2$[A] term in the denominator becomes negligible in comparison with the $k_3$ term.

$$\text{rate} = \frac{k_1 k_3 [A]^2}{k_3} = k_1[A]^2$$

Hence, the rate equation is second order with respect to A.

At very high pressures of A, the $k_3$ term in the denominator becomes negligible in comparison with the $k_2$[A] term.

$$\text{rate} = \frac{k_1 k_3 [A]^2}{k_2[A]} = \frac{k_1 k_3}{k_2}[A]$$

Hence, the rate equation is first order with respect to A.

**Q15 (Ans: C)**

The end-point volume, *V*, is independent of temperature as it depends only on the concentrations of HA and NaOH.

The pH at $\frac{1}{2}V$ is equal to the p$K_a$ of the weak acid, HA. As p$K_a$ is affected by temperature, its value will decrease at a higher temperature (as the dissociation of the weak acid is endothermic). Hence, the pH at $\frac{1}{2}V$ also decreases.

**Q16 (Ans: C)**

When solid $CuSO_4$, which is soluble in water, is added to the saturated solution of $PbSO_4$, the increase in concentration of the common ion $SO_4^{2-}$ causes the equilibrium position of the dissolution of $PbSO_4$ to shift left and the solubility of $PbSO_4$ decreases. Thus, $PbSO_4$ will precipitate in the mixture.

**Q17 (Ans: B)**

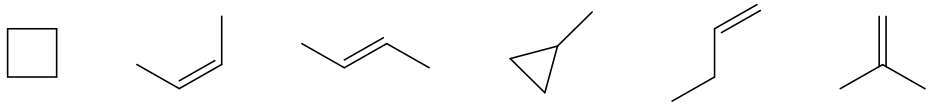
For step 1, using $CH_3Cl$, $AlCl_3$ catalyst will produce methylbenzene, whereas using conc. $H_2SO_4$, conc. $HNO_3$, heat will produce nitrobenzene. As the methyl group is 2-directing while the nitro group is 3-directing, the 2-directing methyl group is preferred as the subsequent group is added to the 2-position.

For step 2, nitration is done before the side-chain oxidation of the methyl group as it is directed to the 2-position relative to the methyl group. If the methyl group were oxidised to the carboxyl group, it will be 3-directing instead.

Hence, the set of reagents and conditions that will give the highest yield of the product is option B.

**Q18 (Ans: C)**

Other than chain isomers (straight-chain and branched), there are also functional group isomers (saturated cycloalkane and alkene), as well as stereoisomers (cis-trans).



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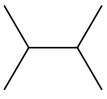
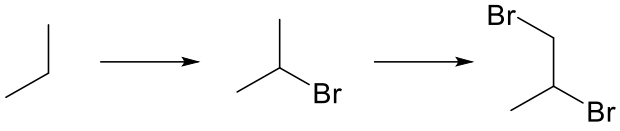
**Q19 (Ans: B)**

Option 1 cannot be formed from two  radicals. Instead, the correct structure is  .

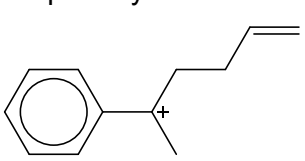
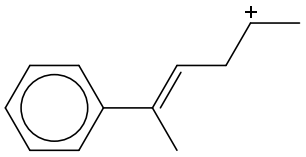
Option 2 cannot be formed from combining  and  radicals.

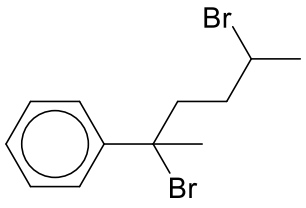
Option 3 is correct as it can be formed from multiple free-radical substitution steps.




**Q20 (Ans: D)**

The tertiary carbocation is more stable than the secondary carbocation, which is more stable than the primary carbocation. Hence, the more stable intermediates of the reaction are

 and  .

This in turn will give rise to the product  .

**Q21 (Ans: B)**

Statement 1 is correct as rotation of plane-polarised light is due to the presence of chiral molecules and a sample that can rotate plane-polarised light is optically active.

Statement 2 is correct as a racemic mixture has equal proportions of both enantiomers, and the enantiomers are chiral molecules. However, a racemic mixture is not optically active as there is no net rotation of plane-polarised light.

**Q22 (Ans: D)**

Option D is correct as chlorine is more electronegative than bromine and the alcohol in option D has two chlorine atoms present. Both chlorine atoms can disperse the negative charge in the conjugate base of the alcohol to a greater extent and thus stabilising the conjugate base to a greater extent.

**Q23 (Ans: B)**

Option B is correct as R−X does not undergo nucleophilic substitution with aqueous NaOH as there is no heating. NaOH will undergo acid-base reaction with carboxylic acid functional group but not the alcohol functional group.

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**Q24 (Ans: C)**

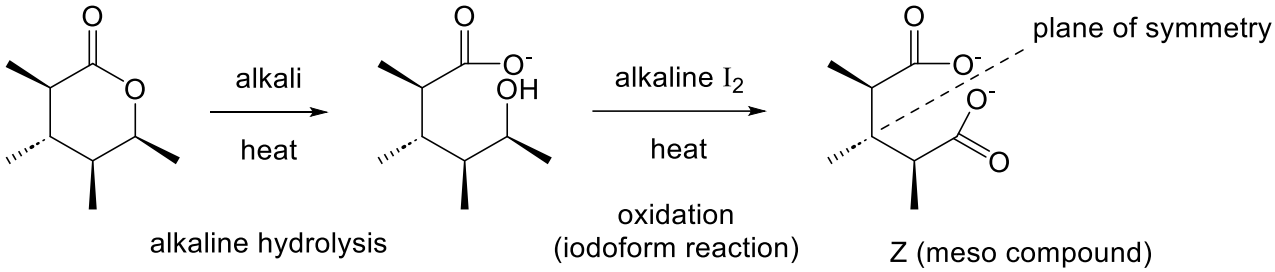
Option A is incorrect as the aldehyde functional group in both S and T will be oxidised by $K_2Cr_2O_7$ to form carboxylic acid.

Option B is incorrect as the aldehyde and ketone functional groups in both S and T will react with 2,4−DNPH.

Option C is correct as only the aliphatic aldehyde functional group in S can be oxidised by Fehling's reagent to give a brick red precipitate while the ketone and aromatic aldehyde functional groups in T do not.

Option D is incorrect as the aliphatic and aromatic aldehyde functional groups in both S and T respectively will react with Tollens' reagent to form silver mirror.

**Q25 (Ans: A)**




Option A is correct as Y first undergoes alkaline hydrolysis (due to the presence of alkali and heating) to give the carboxylate and alcohol functional group. The −CH(OH)$CH_3$ group then undergoes oxidation (iodoform reaction) to form Z which has chiral centres but also a plane of symmetry (meso compound).

Option B is incorrect as there are four oxygen atoms in Z due to the subsequent oxidation (iodoform reaction).

Option C is incorrect as there is no −OH or −COOH group in Z to react with sodium metal to cause effervescence.

Option D is incorrect as there is no H atom which is directly bonded to highly electronegative O atom in Z.

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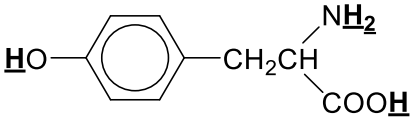
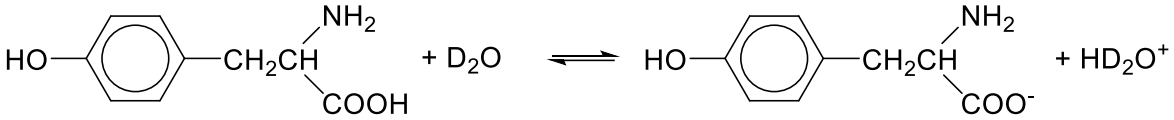
**Q26 (Ans: C)**

The H atoms in tyrosine which could be replaced by deuterium atoms are shown in bold and underlined.

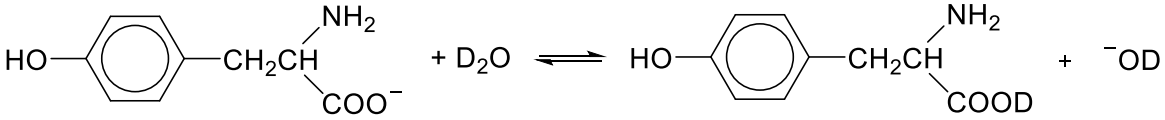


**<u>For phenol and −COOH</u>**
In $D_2O$ solvent, the phenol and −COOH groups can lose $H^+$ to form the respective conjugate bases.

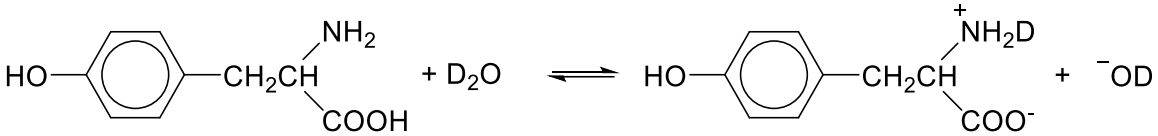
Using the COOH group as an example,



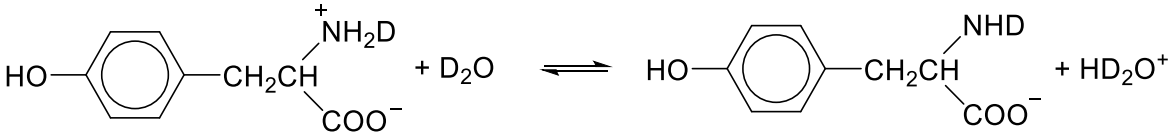
The carboxylate anion can then undergo base hydrolysis with $D_2O$ to form RCOOD as the deuterated solvent is present in large excess.



**<u>For $-NH_2$</u>**
Similarly, in $D_2O$ solvent, the $-NH_2$ group can undergo base hydrolysis to form a conjugate acid.



The conjugate acid can also undergo acid hydrolysis with the possibility of breaking the N−H bond instead of N−D bond, thus replacing the original H atom in $-NH_2$.



Since tyrosine is in dynamic equilibrium in $D_2O$, up to 2 H atoms in $-NH_2$ could be replaced.

**Q27 (Ans: D)**

Option A is incorrect. At standard conditions, the S.H.E. contains 1 bar of $H_2$ gas.

Option B is incorrect. As 1 mole of $H_2SO_4$ ionises to form 2 moles of $H^+$ ions, at standard conditions, the S.H.E. should have 0.5 mol $dm^{-3}$ of $H_2SO_4$, which corresponds to 1 mol $dm^{-3}$ of $H^+$.

Option C is incorrect. The conditions for s.t.p. are 273 K (20 °C) and 1 bar.

Option D is correct. At standard conditions, the S.H.E. is measured at 298 K or 25 °C.

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**Q28 (Ans: A)**

Option A is correct. In the electrolyte, $Cu^{2+}$ is reduced at the cathode while nickel is oxidised at the impure copper anode, forming $Ni^{2+}$ ions. Thus, the concentration of $Cu^{2+}$ ions decreases.

Option B is incorrect. Silver is collected at the bottom of the anode as anodic sludge, and is not oxidised.

Option C is incorrect. Since some nickel is oxidised at the anode before copper is oxidised, less copper is oxidised at the anode compared to the copper ions reduced at the cathode.

Option D is incorrect. Since copper is reduced from $Cu^{2+}$ to Cu, the pure copper needs to be at the cathode where Cu is deposited.

**Q29 (Ans: D)**

Ti has an electronic configuration of [Ar] $3d^2$ $4s^2$.
Its possible oxidation states as a metal cation are: +1, +2, +3 and +4.

The oxidation state of Ti in the respective compounds is
(A) +2
(B) +3
(C) +3
(D) +6

Hence the compound in Option D is unlikely to exist.

**Q30 (Ans: A)**

Option A is correct. Fe has a higher melting point than Mg because Fe forms stronger metallic bonds (greater number of delocalised electrons).

Option B is incorrect. Fe has a higher density than Mg due to Fe having a smaller atomic radius (and hence more atoms per unit volume) and a larger atomic mass than Mg.

Option C is incorrect. While Fe has a higher first ionisation energy, the reason is because the increase in nuclear charge outweighs the increase in shielding effect.

Option D is incorrect. Fe has better electrical conductivity due to having more delocalised electrons because the 3d electrons are also delocalised in the metallic structure of iron.

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