Qn	Ans	Qn	Ans	Qn	Ans	Qn	Ans	Qn	Ans	Qn	Ans
1	**B**	6	**A**	11	**C**	16	**B**	21	**A**	26	**D**
2	**C**	7	**A**	12	**B**	17	**D**	22	**B**	27	**C**
3	**C**	8	**A**	13	**C**	18	**D**	23	**C**	28	**B**
4	**D**	9	**A**	14	**B**	19	**C**	24	**D**	29	**A**
5	**B**	10	**D**	15	**C**	20	**D**	25	**A**	30	**B**

1 Answer: B

The reaction causes the original particle to lose 1 proton, 1 electron and gain 1 neutron.

Options **A** and **C** both have the same number of electrons and protons before and after the reaction.

Option **D** shows a decrease in number of electrons and protons (36 in Kr to 35 in Br) but the number of neutrons remain unchanged (both particles have 40 neutrons).

2 Answer: C

From Figure 1, large increase between the 2nd and 3rd electron removed indicates that there are two valence electrons in element **P**. Hence element **P** is in group 2.

P$^+$: ns^1

From the electronic configuration of **P**$^+$, the point corresponding to the second IE of element **P** is **C**.

3 Answer: C

×**A** $SiCl_4$ has 4 bond pairs and no lone pairs around Si → bond angle is 109.5 °.

×**B** SO_2 has 2 bond pairs and 1 lone pair around S → bond angle is < 120 °.

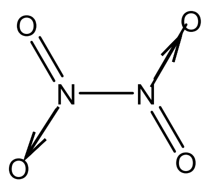
✓**C** IF_2^- has 2 bond pairs and 3 lone pairs around I → bond angle is 180 °.

×**D** CH_3^+ has 3 bond pairs and no lone pairs around C → bond angle is 120 °.

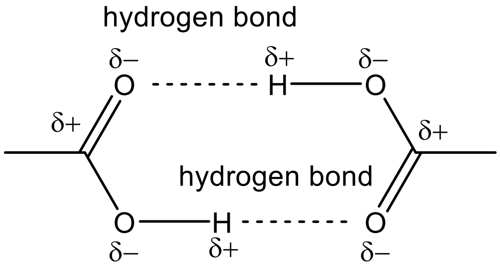
4 Answer: D

✓**A** and **B**

The structures of N_2O_4 and $(CH_3CO_2H)_2$ dimers are shown below.



N_2O_4



$(CH_3CO_2H)_2$

✓**C** The CH_3 groups in $(CH_3CO_2H)_2$ is still tetrahedral around the C, thus the dimer is non- planar.

×**D** Due to p-p orbital overlap, the electrons are delocalised across the O=N-O bond, making all the nitrogen-oxygen bonds to be of the same strength and thus of the same length.

5	**Answer: B** A_r of Si $= \left(\frac{92.2}{100}\times 28\right)+\left(\frac{4.7}{100}\times 29\right)+\left(\frac{3.1}{100}\times 30\right)=28.109$ **×A** A_r of Si = 28.099 **×C** A_r of Si = 28.668 **×D** A_r of Si = 28.854
6	**Answer: A** Since 1 $CH_4 \equiv$ 2 O_2 50 cm^3 of CH_4 requires 100 cm^3 of O_2 for complete reaction. Since CO_2 will be absorbed by the alkaline KOH, it will not be collected. Volume of gas collected = volume of O_2 left $= 150 - 100 = 50$ cm^3
7	**Answer: A** Total amount of heat evolved $= \frac{m}{46.0}\times 1371$ **kJ** Total amount of heat transferred $= 300\times c\times \Delta T$ J $= \frac{300\times c\times \Delta T}{1000}$ **kJ** $\therefore$ efficiency $= \frac{300\times c\times \Delta T}{1000} \div \frac{m\times 1371}{46.0}\times 100\% = \frac{300\times c\times \Delta T\times 46.0}{1000\times m\times 1371}\times 100\%$
8	**Answer: A** Using ΔG = ΔH – TΔS, the negative gradient of the graph in the Ellingham diagram corresponds to ΔS of the reaction. Reaction II has a gradient of zero, that means ΔS = 0 (**reject options B and C**) Reaction I has a positive gradient, that means ΔS < 0 ➔ decrease in disorderedness Reaction III has a negative gradient, that means ΔS > 0 ➔ increase in disorderedness
9	**Answer: A** The graph shows that when pressure increases, % products at equilibrium decreases. ➔ POE shifts left to form less gas molecules (**reject options B and C**) The graph also shows that when temperature increases, % products at equilibrium increases ➔ POE shifts right to favour endothermic reaction (**reject option D**)

10 **Answer: D** (2 and 4 only)

At time t, the change caused POE to shift right to form more SO_3.

×**1** Adding a catalyst will not cause a shift in POE.

✓**2** When temperature decreases, POE shift right to favour exothermic reaction.

×**3** The addition of inert gas at constant volume results in the partial pressures of all gases to remain unchanged. POE will not shift.

✓**4** At equilibrium before time t:

From graph: $n_{SO_2} = 0.5$ mol and $n_{SO_3} = 0.3$ mol

$$n_{O_2} = 0.4 - \frac{0.80-0.50}{2} = 0.25 \text{ mol}$$

$$\therefore K_c = \frac{[SO_3]^2}{[SO_2]^2[O_2]} = \frac{\left(0.3/10\right)^2}{\left(0.5/10\right)^2\left(0.25/10\right)} = 14.4 \text{ mol}^{-1} \text{ dm}^3$$

11 **Answer: C**

$$pOH = pK_w - pH = -\lg\left(2.4\times10^{-14}\right) - 7.4 = 6.22$$

$$\therefore \left[OH^-\right] = 10^{-6.22} = 6.03\times10^{-7}$$

12 **Answer: B**

Since equal volumes of the solutions are used:

$$\text{ionic product of } PbX_2 = \left(\frac{0.100}{2}\right)\left(\frac{1.0\times10^{-2}}{2}\right)^2 = 1.25\times10^{-6} \text{ mol}^3 \text{ dm}^{-9}$$

Since ionic product is less than the K_{sp} of $PbCl_2$ and $PbBr_2$ but larger than the K_{sp} of PbI_2, only PbI_2 will precipitate out.

13 **Answer: C**

When temperature increases, POE shifts left to favour endothermic reaction

➔ K_p will decrease (**reject options A and B**)

When temperature increases, **both** forward and backward rate increases. Since POE is shifting left, the backword rate increases more. (**reject option D**)

14 **Answer: B** (1 and 2 only)

Using the Boltzmann Distribution:

✓**1** increasing temperature increases the number of molecules with energy ≥ Ea

✓**2** When more gas is added at the same temperature and volume, the number of molecules with a particular energy all increases.

×**3** Compressing the gas increases pressure, but will not change the energy distribution of the molecules.

15 **Answer: C** (2 and 3 only)

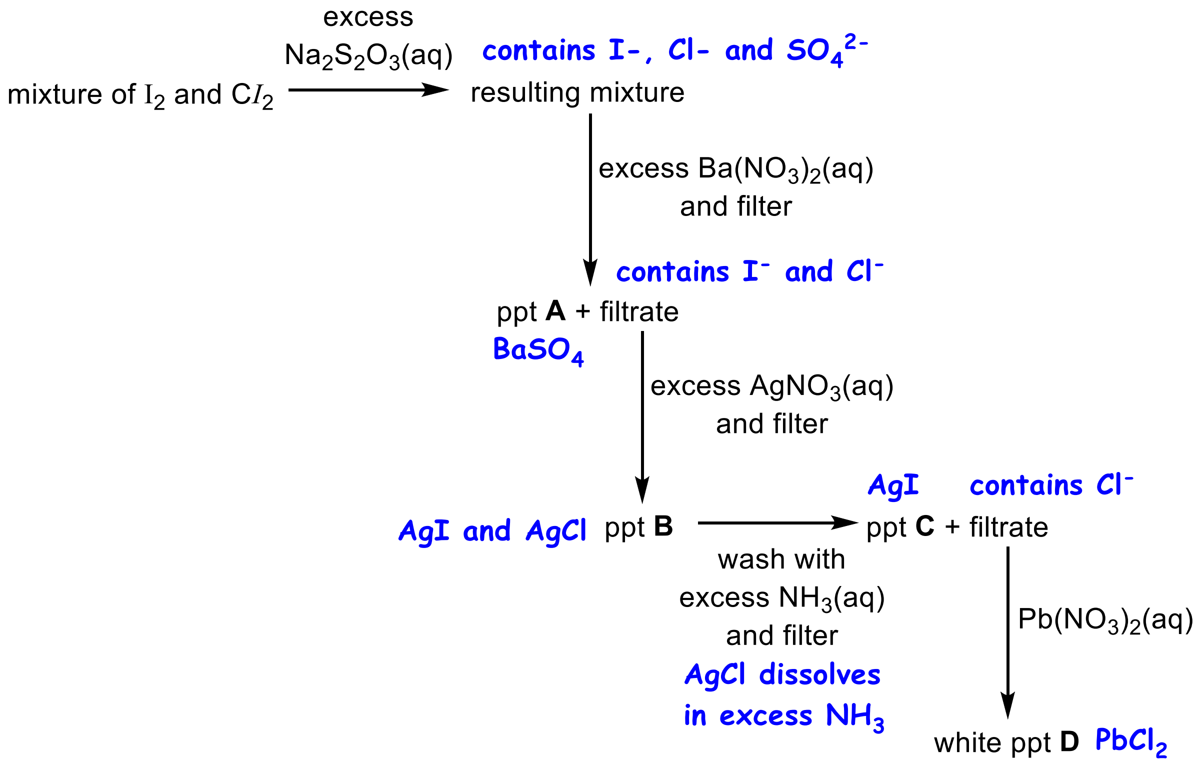
×**1** A catalyst reduces the activation energy of the reaction by providing an alternative pathway/mechanism of lower activation energy. The KE of the reacting particles are not affected.

✓**2** A catalyst increases both the forward and backward rate of a reversible reaction by the same extent.

✓**3** See definition of the catalyst in option 1.

16	**Answer: B** From Data Booklet: $2H^+ + 2e \ll H_2$ 0.00V For the metal not to dissolve, E_{cell} for the reaction must be negative. ×**A** $Cr^{2+} + 2e \ll Cr$ –0.91 V ➔ E_{cell} = 0.00 – (–0.91) = +0.91 V ✓**B** $Cu^{2+} + 2e \ll Cu$ +0.34 V ➔ E_{cell} = 0.00 – (+0.91) = –0.34 V ×**C** $Fe^{2+} + 2e \ll Fe$ –0.44 V ➔ E_{cell} = 0.00 – (–0.44) = +0.44 V ×**D** $Pb^{2+} + 2e \ll Pb$ –0.13 V ➔ E_{cell} = 0.00 – (–0.13) = +0.13 V
17	**Answer: D** ×**A** To obtain pure copper, the pure copper electrode should be the anode (negative electrode) which is electrode **Q**. ×**B** [$CuSO_4$] remains unchanged as the amount of Cu^{2+} that is oxidised at the anode is replenished by the amount of Cu that is reduced at the cathode. $Q = (40.0)(26.8 \times 60) = n(96500)$ $n_e = 0.666$ mol Since 1 Cu $\equiv$ 2e Mass of Cu $= \dfrac{0.666}{2} \times 63.5 = 21.2$ g (**option C is wrong**) % by mass of Ag $= \dfrac{26.47 - 21.2}{26.47} \times 100 = 20$ %
18	**Answer: D** From graph, the sharp drop in ΔH (and hence the boiling point) from **B** to **C** signifies the change from giant structure to simple covalent molecules (group 14 to group 15 element). ×**A** Element **E** is in group 17 and Element **F** is in group 18. Both are non-polar molecules thus will both be soluble in warm benzene (non-polar solvent). ×**B** Elements **A**, **B** and **C** are in groups 13, 14 and 15 respectively. The chlorides of these elements are acidic since the structure of the chlorides are becoming increasingly covalent in nature. ×**C** Element **G** is in group 1 and Element **D** is in group 16. The oxide of **G** (basic oxide) and the oxide of **D** (acidic oxide) will form a neutral salt. ✓**D** Oxide of A could be Al_2O_3 which will react with excess NaOH to from $Al(OH)_4^-$ complex.

19 Answer: C



20 Answer: D

Reagent and conditions to convert alcohol to alkene: conc. H_2SO_4, heat

➔ reagent **L** is conc. H_2SO_4 (**reject options A and B**)

Reagent **M** cannot be ethanolic as the alkene will dissolve in the organic solvent, making collection difficult. (**reject option C**)

21 Answer: A (1, 2 and 3)

✓**1** $$CH_2{=}CH_2 \xrightarrow{DCl} CH_2DCH_2Cl$$

✓**2** $$CH_3CN \xrightarrow[D_2O]{D_2SO_4,\ heat} CH_3COOD$$

✓**3** $$CH_3CH_2OH \xrightarrow[D_2O]{I_2,\ NaOD,\ heat} CDI_3 + HCO_2^-$$

22 Answer: B

✓**A** $(CH_3)_3COH$ acts as an base to accept H^+ to from the conjugate acid $(CH_3)_3CO^+H_2$

×**B** HCl acts as an acid to protonate the –OH group in $(CH_3)_3COH$ to make it a better leaving group so as to form the carbocation in step 2.

✓**C**
$$(CH_3)_3COH + HCl \xrightarrow{fast} \cancel{(CH_3)_3C\overset{+}{O}H_2} + \cancel{Cl^-}$$

$$\cancel{(CH_3)_3C\overset{+}{O}H_2} \xrightarrow{slow} \cancel{(CH_3)_3\overset{+}{C}} + H_2O$$

$$\cancel{(CH_3)_3\overset{+}{C}} + \cancel{Cl^-} \xrightarrow{fast} (CH_3)_3CCl$$

✓**D** Steps 2 and 3 are representative of the S_N1 mechanism.

23 **Answer: C**

If the reaction is an elimination reaction or an S_N1 reaction, the resulting mixture will be a racemic mixture with no optical activity. (**reject options A and D**)

If the reaction is an SN2 reaction, there will be an inversion of stereochemistry, which causes rotation of plane polarised light in the opposite direction (**reject option B**).

24 **Answer: D**

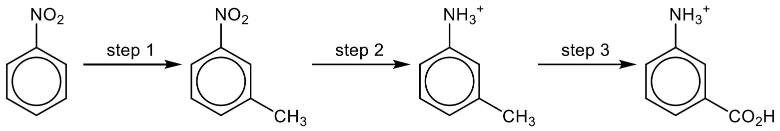
For Ag**X**(s) to be formed, the alkyl halide has to undergo hydrolysis first so that the free halide ion can be formed.

The rate of hydrolysis is determined by the strength of the C–X bond.

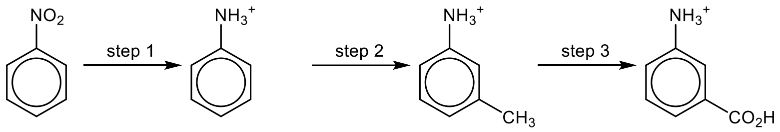
*<u>Note</u>: Options **A**, **B** and **C** are correct factual statements, but they do not explain the observation given in the question.*

25 **Answer: A** (1 and 2 only)

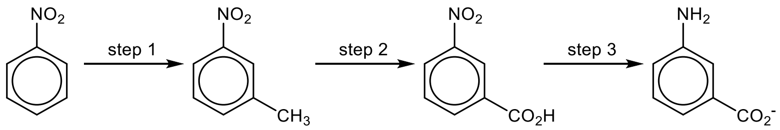
✓**1**



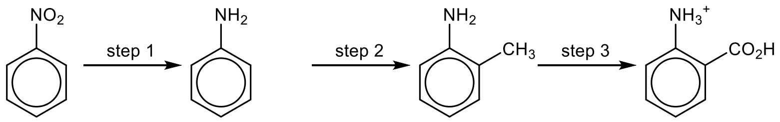
✓**2**



×**3**



×**4**



26 **Answer: D** (1 only)

×**1** DIBP does not have $-COCH_3$ and $-CH(OH)CH_3$ group present in the structure to give a positive iodoform test.

✓**2** The ester undergoes acid hydrolysis first and the primary alcohol formed undergoes oxidation, decolourising purple $KMnO_4$.

✓**3** The ester undergoes acid hydrolysis and the 1,2-dibenzoic acid which requires 2 mol of NaOH for complete neutralisation.

27 **Answer: C**

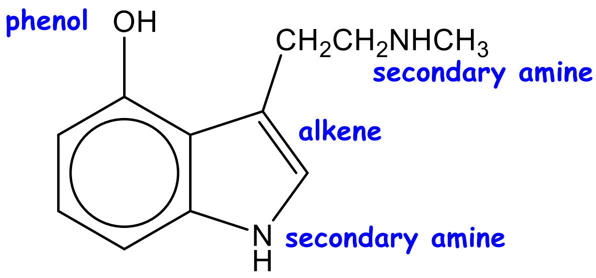
Compound **A** is an amide which is neutral.

Compounds **B**, **C** and **D** are secondary amines.

Compound **B** has an electron-withdrawing C*l* group which makes the lone pair on the N less available for protonation.

Due to p-p orbital overlap, the lone pair on N in compound **D** is delocalised into the C=C alkene, making it less available for protonation.

28 **Answer: B** (2, 3 and 4)



Compound **W**

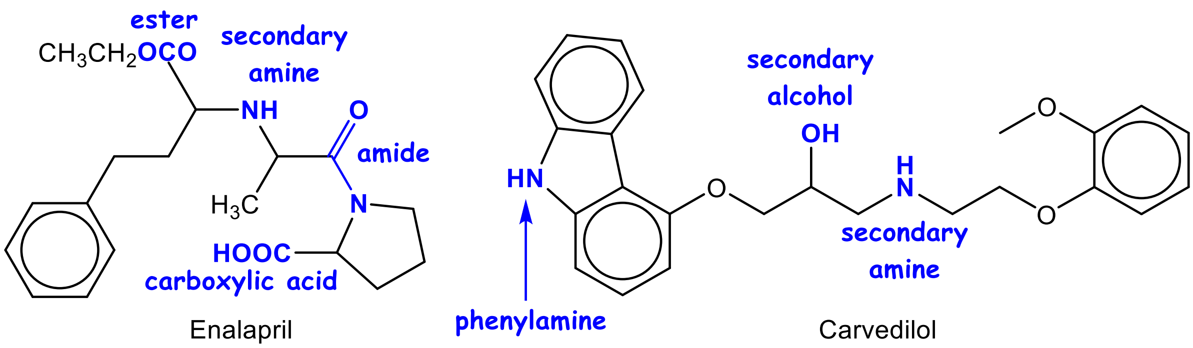
✗**1** The acidic group (phenol) is more acidic than ethanol, and thus will have a lower pK_a.

✓**2** The acidic phenol group will react with bases, and the alkaline amine group on the side chain will react with acids.

✓**3** The amines will react with CH_3COCl to from the amide and white fumes of HCl.

✓**4** Due to p-p orbital overlap, the lone pair on O in phenol is delocalised into the benzene ring, making phenol a weaker nucleophile for condensation to take place during ester formation.

29 **Answer: A** (1 and 2)



Enalapril

Carvedilol

✓**1** The phenylamine is Carvedilol will decolourise orange Br_2(aq).

✓**2** The carboxylic acid in Enalapril will form CO_2(g) with aqueous sodium carbonate.

✗**3** The primary alcohol formed after acid hydrolysis of Enalapril and the secondary alcohol in Carvedilol will decolourise purple $KMnO_4$(aq).

30 **Answer: B**

Only option B is able to account for all the fragments generated by the two enzymes. All the other options have one fragment (either from the first or second enzyme) missing.

✗**A** missing the fragment tyr-leu-leu from the first enzyme

✗**C** missing the fragment leu-try from the second enzyme

✗**D** missing the fragment tyr-ala from the first enzyme