2017 H2 Chemistry Paper 1 Worked Solution

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

1 Amt of $KMnO_4$ used for first experiment = 0.1 x 15/1000 = 1.5×10^{-3} mol

$5Fe^{2+} + MnO_4^- + 8H^+ \rightarrow 5Fe^{3+} + Mn^{2+} + 4H_2O$

Amt of Fe^{2+} present = 1.5×10^{-3} x 5 = 7.5×10^{-3} mol

$[Fe^{2+}] = 7.5 \times 10^{-3} / (25/1000) = 0.3$ mol dm^{-3}

Amt of $KMnO_4$ used for second experiment =0.1 x 34.2/1000 = 3.42×10^{-3} mol

Amt of Fe^{2+} present = 0.0171 mol

Amt of Fe^{3+} originally in 25 cm^3 = $0.0171 - (7.5 \times 10^{-3}) = 9.6 \times 10^{-3}$ mol

$[Fe^{3+}] = 9.6 \times 10^{-3} / (25/1000) = 0.384$ mol dm^{-3}

Ans: C

2 9 x 4 = 36 nuclides were lost, hence the mass number of element A is now 241 – 36 = 205.

9 x 2 = 18 protons were lost, hence the atomic number of element A before accounting for the electrons is 94 – 76. However, the implication of $_{-1}^{0}e$ is that each electron lost increases the atomic number by 1, so 5 electrons means that the atomic number increases by 5. Hence 76 + 5 = 81.

Ans: A

3 A is not correct. From NH_3 to H_2S, the shape changes from trigonal pyramidal to bent, hence the bond angle actually decreases.

B is correct. PH_3 has a smaller bond angle than NH_3 as P is less electronegative than N, hence the bond pairs are further away from the central atom and experience less bond–pair–bond pair repulsion, hence leading to a

smaller bond angle in PH_3. $AlCl_3$ has a larger bond angle than NH_3 as it is trigonal planar with a bond angle of 120 º.

C is not correct. From PH_3 to PF_3, H is less electronegative than F, hence the bonding electron pairs are closer to the central atom in PH_3, hence experience greater bond–pair–bond pair repulsion, hence leading to a greater bond angle in PH_3. From PH_3 to PF_3, there is a decrease in bond angle.

D is not correct. XeF_4 is square planar with bond angle of 90º. SCl_6 is also square planar with bond angle of 90º. Hence there is no increase in bond angle.

Ans: B

4 Glycine forms zwitterions and has an ionic lattice structure with strong electrostatic forces of attraction between the zwitterions, hence has a higher melting point than 2–hydroxyethanoic acid.

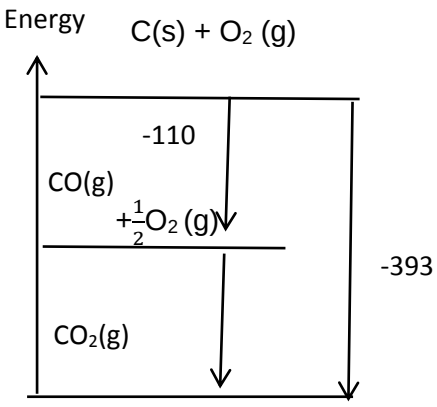
Ans: C

5 pV = nRT. For fixed mass of gas at constant T, pV α k. Hence graph should be horizontal line with gradient k.

At lower T, pV should be be lower than original.

Ans: C

6



Ans: A

7 $\Delta G = \Delta H - T\Delta S$

ΔH will be positive, because interactions in the protein are broken going to the unfolded state. ΔS will also be positive, because the unfolded state is more disordered with coil being more random. ΔG is negative as denaturation is spontaneous when egg is cooked.

Ans: A

8 At a higher temperature, the graph is skewed towards the right. Area under the graph represents the number of molecules with energy greater than or equal to E_A.

Ans: B

9 Since total vol is constant, [reactants] is α to its vol

Rate α 1/time

Comparing expt 1 & 2, when $[I^-]$ increases 1.5 times, rate increases 170/113 = 1.5 times. Hence 1st order wrt $[I^-]$

Comparing expt 2 and 3, $[S_2O_8^{2-}]$ increases 2 times, rate increases 113/56.5 = 2 times. Hence 1st order wrt $[S_2O_8^{2-}]$

⇨ Rate = k $[S_2O_8^{2-}][I^-]$

Comparing Expt 1 & 4, when $[I^-]$ increases 2 times and $[S_2O_8^{2-}]$ increases 4 times, rate should increase 8 times. Hence time in Expt 4 = 170/8 = 21.3 s.

Since Rate = k $[S_2O_8^{2-}][I^-]$, slow step should involve 1 mole of $(NH_4)_2S_2O_8$ and 1 mole of KI. Since overall eqn involves 2 moles of I^-, the reaction must have more than 1 step. Hence reaction should involve intermediates.

Fe^{2+} can act as homogenous catalyst in the reaction which is slow due to the reaction between two anions:

Step 1: $\mathbf{2Fe^{2+} + S_2O_8^{2-} \rightarrow 2Fe^{3+} + 2SO_4^{2-}}$

$E^{\ominus}_{cell}$ = +2.01 – (+0.77) = + 1.24 V (> 0, reaction is feasible)

Step 2: $\mathbf{2Fe^{3+} + 2I^- \rightarrow 2Fe^{2+} + I_2}$

$E^{\ominus}_{cell}$ = +0.77 – (+0.54) = + 0.23 V (> 0, reaction is feasible)

Ans: C

10 A: When acid is added, NH_3 is removed. Hence POE will shift left and white precipitate of AgC*l* is formed.

B: K_c expression does not include solids.

C: K_c expression is not affected by concentration

D: Removing solid does not shift POE.

Ans: A

11

$2SO_3\,(g) \rightleftharpoons 2SO_2\,(g) + O_2(g)$

Initial/atm	x	0	0
Eqm/atm	0.5x	0.5x	0.25x

0.5x+0.5x+0.25x = 1.2

x = 0.96

Mole fraction of O_2 = 0.25(0.96) / 1.2 = 0.2

Alternatively,

$2SO_3\,(g) \rightleftharpoons 2SO_2\,(g) + O_2(g)$

Initial/mol	x	0	0
Eqm/mol	0.5x	0.5x	0.25x

Mole Fraction of O_2 = (0.25x)/ (0.5x+0.5x+0.25x) = 0.2

Ans: B

12

1) HI is a strong acid. $CH_3CH_2NH_2$ will be protonated. No more weak base present. Not a buffer.

2) 2 mol of HCl and 2 mol of CH_3COOH will be formed from the hydrolysis of CH_3COCl . 2 mole of HCl reacts with 2 moles of NaOH, leaving 1 mole of NaOH. 1 mol of CH_3COONa will be formed from the acid base reaction of 2 moles of CH_3COOH with 1 mole of NaOH, leaving 1 mol of CH_3COOH. Since there is 1 mol of

CH_3COONa and 1 mol of CH_3COOH, a buffer is formed (Think about the species and the possibility of reacting)

3) H_2SO_4 is a stong dibasic acid which will cause $CH_3CH_2NH_2$ to be protonated. Not a buffer

Ans: A

13 $MX_2\ (s) \rightleftharpoons M^{2+}\ (aq) + 2X^-\ (aq)$

$LY\ (s) \rightleftharpoons L^+\ (aq) + Y^-\ (aq)$

A: Ksp increase only when the fwd reaction is endothermic while Ksp decrease when the reaction is exothermic.

B: For solute containing different number of ions, solubility should be calculated to determine which is more soluble. Ksp can only be used for comparison of the no. of ions that made up the two solutes are similar.

C: To calculate for any concentration of ion, it should be IONIC PRODUCT

D: If the solublity of LH is exothermic, a higher temperature will lower the Ksp since the k_b increase a greater extent than k_f.

Ans: D

14 Graph 1: Electronegativity increases across the period.

Graph 2: Si has the highest melting point as it requires the most energy to overcome the strong network of covalent bonding in its giant covalent lattice. P_4 are held by weak id-id interaction, hence low mpt.

Graph 3:

	NaCl	$MgCl_2$	$AlCl_3$	$SiCl_4$	PCl_5
pH	7	6.5	3	1-2	1-2

Ans: D

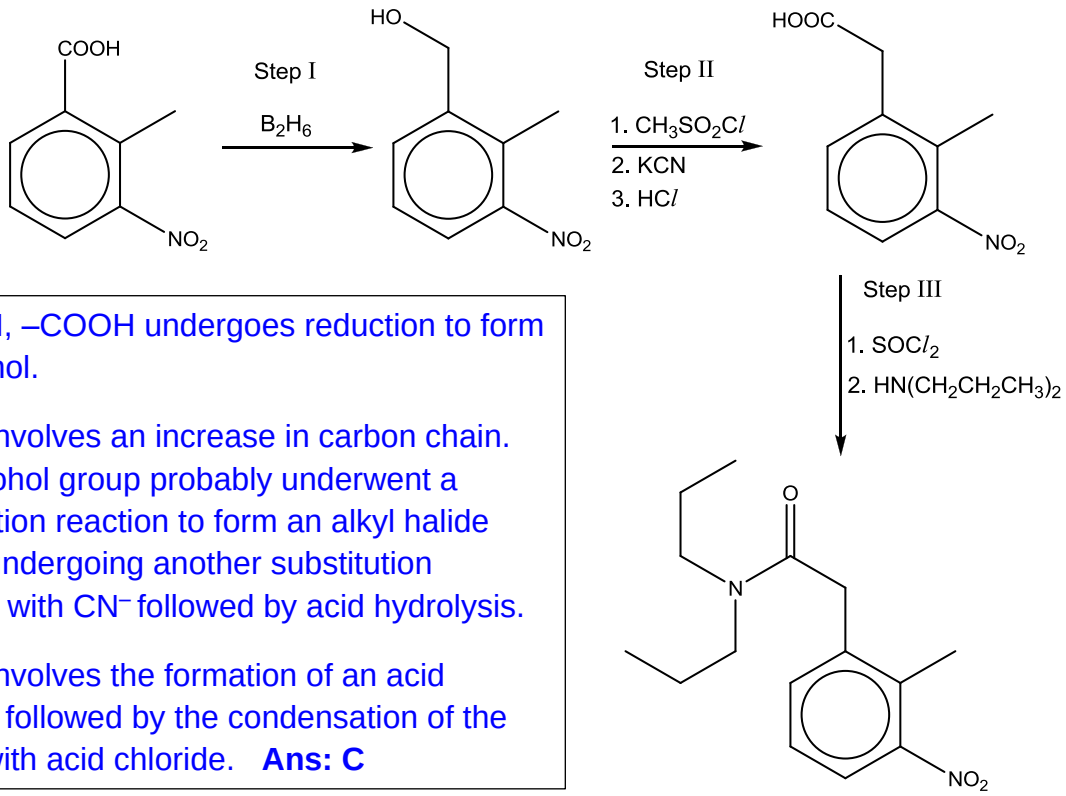
15 1. From the more positive $E^{\ominus}$, it can be seen the X_2 has the greatest tendency to be reduced. Hence, it has the greatest oxidising power.

2. The $E^{\ominus}$cell will be +1.36 – (+0.54) = +1.90 > 0. Hence, the reaction will occur.

3. From the data booklet, Z_2 is I_2 which is the largest atomic radius, so it has the least tendency to attract electrons to form negatively charge species. Hence, lowest E.A.

Ans: C

16 Which of the following shows the correct type of reaction(s) occurring for each step of the synthesis?



In Step I, –COOH undergoes reduction to form an alcohol.

Step 2 involves an increase in carbon chain. The alcohol group probably underwent a substitution reaction to form an alkyl halide before undergoing another substitution reaction with CN^- followed by acid hydrolysis.

Step 3 involves the formation of an acid chloride followed by the condensation of the amine with acid chloride. **Ans: C**

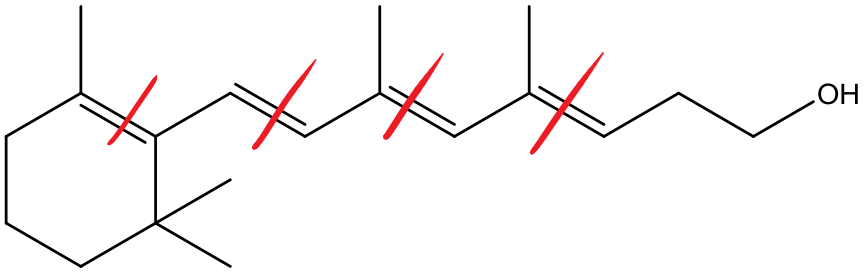
17 The reaction does not have an activation barrier (zero E_A) which means it must be a very energetically favourable reaction which does not involve any bond breaking.

Ans: D

18 **A:** HCl (white fumes) is formed when the alcohol reacts with ethanoyl chloride.

B: is wrong as alkene does not undergo reduction with $LiAlH_4$.

C: is wrong since CO_2 would not be produced when the compound undergoes strong oxidation. No presence of ethanedioic acid that can break down into CO_2.



D: 1 mol of Vitamin A produces 0.5 mol of H_2 and that is 22.7/2 = 11.35 dm^3 at stp.

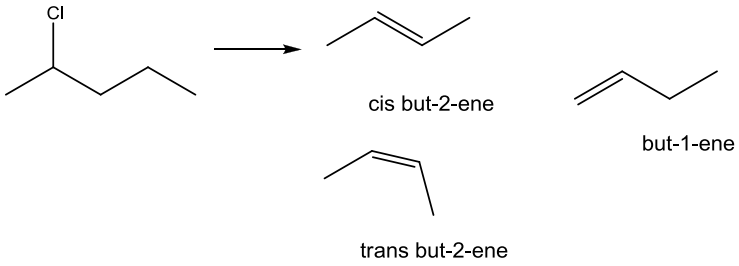
Ans: A

19 Option 1 is wrong since CH_3CH_2CHC/CH_3 undergoes S_N2 nucleophilic to give a optically active product, $CH_3CH_2CH(OH)CH_3$. The product would be a racemic mixture if it underwent S_N1 mechanism.

Option 2 is correct as $CH_3CH_2CH(OH)CH_3$ and $CH_3CH_2CH_2OCH_3$ are functional group isomers.

Option 3 is correct as C–Br bond is weaker than C–Cl bond and so rate of substitution will increase when the sample is 2–bromobutane.

Option 4 is correct as $CH_3CH_2CH(OH)CH_3$ undergoes elimination with conc, H_2SO_4 to give but–1–ene, cis–but–2–ene and trans–but–2–ene.

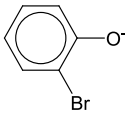


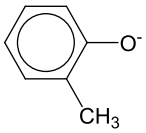
Ans: **D**

20 Conjugate base with smallest pK_b (largest K_b) is the strongest conjugate base; it must come from the weakest acid (smaller K_a).

Strength of acidity is dependent on stability of conjugate anion. The greater the **extent of charge dispersal, the more stable the conjugate anion**.

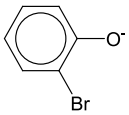
Order of **decreasing stability of conjugate anion**:

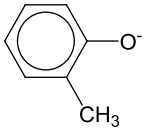




, , $CHF_2CH_2O^-$,$(CH_3)_2CHO^-$

Correct order in increasing K_b:





, , $CHF_2CH_2O^-$,$(CH_3)_2CHO^-$

Ans: **B**

21 Option A is wrong since the intermediate $CH_3CH_2CH(CN)O^-$ has a tetrahedral shape.

Option B is wrong since a racemic mixture of $CH_3CH_2CH(OH)CN$ would be obtained.

Option C is wrong since there are more –R groups surrounding the carbonyl C in propanone, making the C less electron deficient and also hindering the attack of the nucleophile. Hence the rate should be slower.

Option D is correct due to nucleophilic substitution where the Cl is substituted by CN to give the same product. $CH_3CH_2CH(OH)CN$

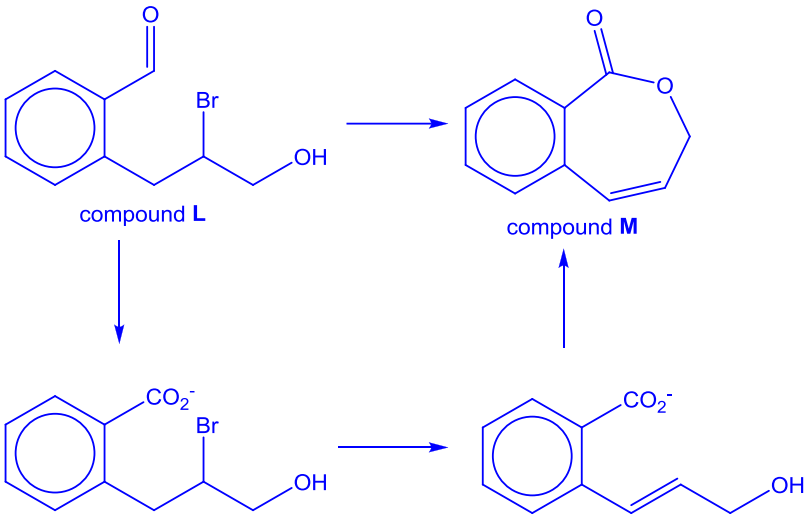
Ans: D

22 Butyl ethanoate is formed from butanol and ethanoic acid

$CH_3CH_2CH_2CH_2O\mathbf{OCCH_3}$ + $\mathbf{H^{18}O}$-H → $CH_3CH_2CH_2CH_2OH$ and $\mathbf{CH_3CO^{18}OH}$

Ans: A

23

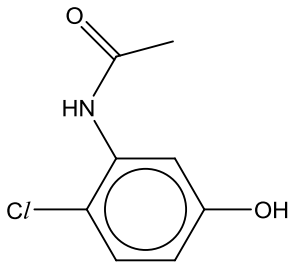


Ans: C

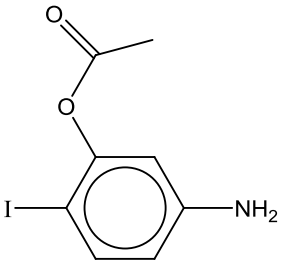
24 α–amino acid has a H_2N-CH(R)- COOH structure. Hence, after oxidative cleavage Option 1 and 4 are probable with the correct empirical formulae.

Ans: B

25 Which of the following reagents would give different observations when added to both compounds in separate test–tubes?



Compound **Y**

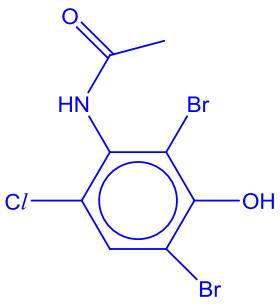


Compound **Z**

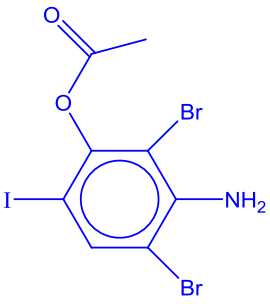
A aqueous bromine

Both compounds would decolourise orange aqueous bromine and form white precipitates.

product of compound **Y**



product of compound **Z**



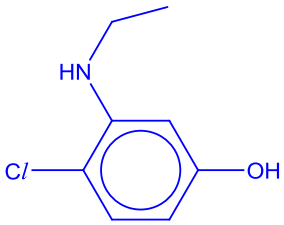
B 2,4–dinitrophenylhydrazine

Neither compounds have carbonyl functional groups and hence not form orange precipitate.

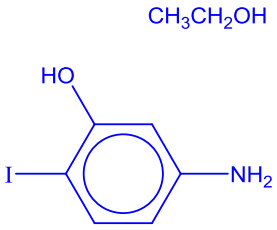
C $LiAlH_4$ in dry ether, followed by hot acidified $KMnO_4$

Both compounds would undergo reduction with $LiAlH_4$ and form the following :

product of compound **Y**



products of compound **Z**



The ethanol would undergo oxidation and decolourise $KMnO_4$.

D ethanolic silver nitrate

Aryl halides would not form precipitate with ethanolic silver nitrate.

Ans: C

26

1. Acid chloride reacts with phenol and alcohol to form ester and amine to form amide. Note that the lone pair of e on N (next to the C=C) is delocalised into the double bond hence nucleophilic subst to form amide is not possible.
2. Alkenes and ketones can be reduced by hydrogen gas to form alkane and secondary alcohol respectively.

3. HBr(g) can react with the alkene via electrophilic addition, the aliphatic alcohol to form RBr via nucleophilic substitution, and both amine functional groups in an acid base reaction.

Ans: B

27 Lone pair of electron on O in alcohol is donated into the empty orbital of H^+.

Ans: B

28 Sucrose is oxidised to carbon dioxide gas while oxygen is reduced to water. Hence electrons will flow from left (anode) to right (cathode).

$E^{\theta}(O_2/H_2O) = +1.23$ V

$+1.25 = +1.23 - E^{\theta}_{(anode)}$

$E^{\theta}_{(anode)} = -0.02$ V **Ans: A**

29 Since 1 mol of complex forms 2 mol of AgI (s), only one iodide ion is present in the complex. Therefore, there should be 5 ammonia ligands in the complex (since complex has co-ordination number 6). Y is $[Cr(NH_3)_5I]\ I_2$.

Ans: C

30 1) Q can use its 3 unpaired 3d and 4s electrons to form ions or bonds hence can exhibit oxidation states from +1 to +5. Therefore $\mathbf{Q_2O_3}$ (oxidation number of Q is +3) is likely to exist.

2) R has a higher nuclear charge than P. Although R has additional electrons (i.e. the 10 3d electrons) in an inner sub–shell, they provide relatively poor shielding (when compared to the 3s and 3p electrons) to the outermost 4s electrons because they are occupying highly diffuse d orbitals. (strength of shielding effect: s > p > d). Hence, the valence 4s electrons of R experience greater effective nuclear charge and are attracted more strongly to the nucleus, resulting in R having a larger 1st IE than P.

3) R^+ has a fully filled d orbital hence d–d transition is not able to take place. Hence the compound is a white solid.

Ans: D