2014 H1 Chem Prelims P1 (Worked Solution)

1 No. of moles of ethene = 14/28 = 0.5

Thus, given that each ethene molecule has 6 atoms (2 carbon atoms and 4 hydrogen atoms)

No. of atoms of ethane = 0.5 x 6 = 3

A: No. of moles of sodium = 11.5 / 23 = 0.5

Therefore, no. of atoms = 0.5 (since sodium metal only has 1 atom)

B: No. of moles of methane = 14 / 16 = 0.875

Therefore, no. of atoms = 0.875 x 5 = 4.375 (since methane has 5 atoms, 1C and 4H)

C: No. of moles of carbon dioxide = 44 / 44 = 1

Therefore, no. of atoms = 1 x 3 = 3 (since carbon dioxide has 3 atoms, 1C and 2O)

D: No. of moles of sodium = 96 / 32 = 3

Therefore, no. of atoms = 3 x 2 = 6 (since oxygen is diatomic, 2O)

Ans: C

2 **A** Both isotopes have the same number of protons but different number of electrons.

By definition, isotopes have the same number of protons and electrons but different number of neutrons and hence false

B The most abundant isotope of chlorine is ^{35}Cl.

With an average Ar of 35.5 (data booklet), it shows that ^{35}Cl is more abundant than ^{37}Cl as the average Ar is nearer to 35 than 37. Thus, the statement is true **(Ans)**.

C The isotopes of chlorine exhibit different chemical properties.

Isotopes have the same chemical property and hence false.

D The number of neutrons in ^{37}Cl is 18.

No. of neutrons = 37 – 17 = 20 not 18 and hence false.

3 Since hydrocarbon is burnt in excess oxygen, complete combustion will take place.

After complete combustion, there is excess oxygen, carbon dioxide and steam/water in gaseous form.

When cooled to room temperature, gaseous water will become liquid water and hence the decrease by 90cm^3 was the volume of water produced.

The concentrated base would then react with the carbon dioxide produced and hence the decrease by 120cm^3 is the volume of carbon dioxide produced.

$C_xH_y + (x+y/4)O_2 \longrightarrow xCO_2 + (y/2)H_2O$

Value of x = 120 / 30 = 4

Value of (y/2) = 90/30 = 3 thus y = 6

(x + y/4) = (4 + 6/4) = 5.5

Since 30cm^3 hydrocarbon is used, minimum volume of oxygen needed = 5.5 x 30 = **165cm^3**

Ans: C

4 Since the metal ion is oxidised from M^{2+} to M^{4+}, each mole of the metal would take in 2 electrons.

Acidified $K_2Cr_2O_7$ would release 6 electrons for each mole of $Cr_2O_7^{2-}$

Thus, for a balance equation between $Cr_2O_7^{2-}$ and M^{2+}, the **mole ration between $Cr_2O_7^{2-}$ and M^{2+} would be 1 : 3**

For this question, the no. of moles of M^{2+} = (25/1000) x 0.2 = 0.005

Therefore, (based on the mole ratio determined)

The number of moles of $Cr_2O_7^{2-}$ required = 0.005 / 3 = 0.00167

Thus, volume of $Cr_2O_7^{2-}$ required = 0.00167 / 0.05 = 0.0333 dm^3 = 33.3 cm^3

Ans: A

5 The largest jump in IE is between the 6th and the 7th electron.

Hence, element **E** is from **Group 6**.

A It has a valence electronic configuration of $ns^2\ np^4$.

All group 6 elements have this configuration.

B It is a simple covalent compound with weak intermolecular forces of attraction.

With an Ar of less than 130, all the elements in group 6 with Ar below 130 are non-metals and hence have weak intermolecular forces of attraction.

C It usually forms an ionic compound with a charge of -2.

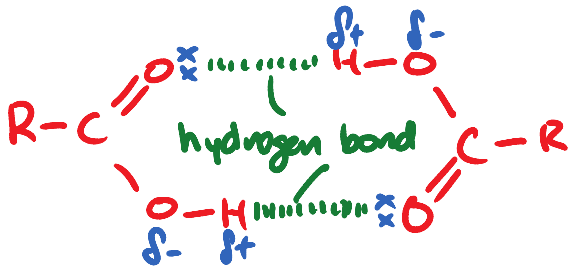
Being in group 6, when it forms an ionic compound, it will usually obtain a charge of -2

D It is from Period 4.

This information cannot be determined from the information given in the question as element can be from Period 2 to 5 but cannot be certain its definitely from Period 4. **(Ans)**

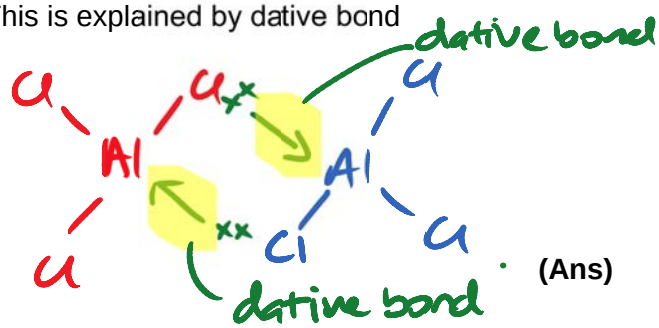
6 **A** The dimerisation of carboxylic acids.

This is explained by hydrogen not dative bond.



B The dimerisation of $AlCl_3$.

This is explained by dative bond



(Ans)

C The formation of N_2O_4 from NO_2.

This is a normal covalent bond between the 2 lone electrons, one each on each NO_2 molecule.

D The formation of a salt from an acid base reaction.

The salt formed usually involves an ionic bond but not a dative bond.

7 To be collected first for distillation, it means the compound has the **lowest** boiling point

A $CH_3CH(CH_3)CH_3$ (Non-polar thus id-id)

B $CH_3CH_2CH_2CH_2NH_2$ (hydrogen bonding due to H directly attached to N at NH_2)

C $CH_3CH_2CH_2CH_2OH$ (hydrogen bonding due to H directly attached to O at OH)

D $CH_3CH_2CH_2CH_3$(Non-polar thus id-id)

A and D have the weaker intermolecular force among the 4 and both A and D have the same number of electrons.

However A is **more branched** than D and hence have a **less extensive id-id** as compared to D and hence a lower boiling point

Ans: A

8 Standard enthalpy change of neutralisation is defined as producing **1 mole of water** from a reaction between an acid and a base.

Only Option D produced one mole of water from the reaction between an acid and a base.

Ans: D

9 Dynamic equilibrium by definition is reached when the rate of the forward reaction is equal to the rate of the backward/revers reaction

Ans: D

10 **A** Increasing the pressure of the system would produce more CO_2.

System will try to decrease pressure by favouring the side with less moles of gas, which is to shift equilibrium to the left and produced less CO_2 not more.

B Increasing the temperature of the system will cause less CO_2 to be produced.

System will try to reduce the temperature by favouring the endothermic reaction (forward reaction), which is to shift equilibrium to the right and thus produce more CO_2 not less.

C Removing CO_2 from the system will not change the K_c value of this equilibrium.

Although there will be a shift in equilibrium, K_c value does not change as there is no change in temperature hence this is correct **(Ans)**

D The unit for the K_c of this equilibrium is $mol^{-1}\ dm^3$.

Units for this would be $moldm^{-3}$ not $mol^{-1}dm^3$.

11 To increase the % of NH_3, equilibrium needs to shift to the right.

(*Temperature)*

For this to take place, temperature needs to decrease since the forward reaction is exothermic. Hence, $T_2 < T_1$

To decrease the % of NH_3, equilibrium needs to shift to the left

(Pressure)

For this to take place, pressure needs to decrease as there are more number of moles of gas on the reactant side. Hence, P_2<P1

Ans: A

12 For 1 dm^3 of 0.100 mol dm^{-3} H_2SO_4

$[H^+] = 0.1 \times 2 = 0.2$

No. of moles of H^+ = 0.2 (since volume = 1dm^3)

For pH 2,

$[H^+] = 10^{-2} = 0.01$

Let the new volume of solution be x

Thus, (0.2 /x) = 0.01

x = 20 dm^3, thus volume of water needs to be added = 20 – 1 = 19 dm^3

Ans = B

13 Using expt 1 and 2, keeping [**H**] constant, when [**G**] double, initial rate also doubles.

Thus, order of reaction w.r.t [**G**] is 1.

Using expt 1 and 3, keeping [**G**] constant, when [**H**] double, initial rate also quadruples.

Thus, order of reaction w.r.t [**H**] is 2.

Thus, using expt 1 as a reference, when [**G**] triples and keeping [**H**] constant, initial rate will triple to 3 (1 x 3). Then, when [**H**] halved and keeping [**G**] constant, initial rate will triple drop by ¼ times to ¾.

Ans: B

14 For ionic radius, the biggest difference/jump is between Gp IV and Gp V. Since **J** is at the peak, it must be the Gp V element in Period 3 which is P

Ans: C

15 Options A to C all show an initial increasing trend followed by a decreasing one except for the pH of chlorides in water which just decreases across the elements in Period 3.

Ans: D

16 **A** Aluminium has a giant metallic lattice structure

Structure has nothing to do with IE

B Effective shielding provided by the electrons in the 3s orbital

True as this factor outweighs the increase in nuclear change from the element before it

resulting the IE of A*l* to be lower than the element before it. **(Ans)**

C Effective nuclear charge increases across a period

This, although true, is outweighed by the effective shielding of the 3s electrons as well as the fact that the electron removed is in a higher 3p orbital

D Inter-electronic repulsion in the 3p orbital

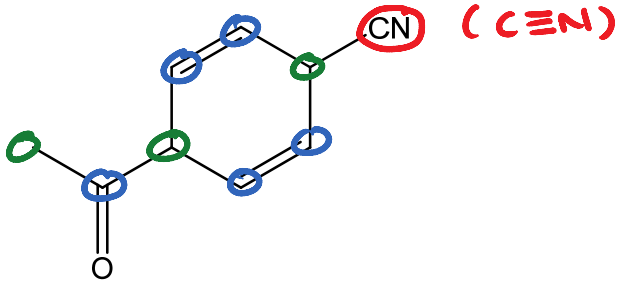
There is none as the 3p orbital of A*l* only has 1 electron

17

red : sp

blue : sp^2

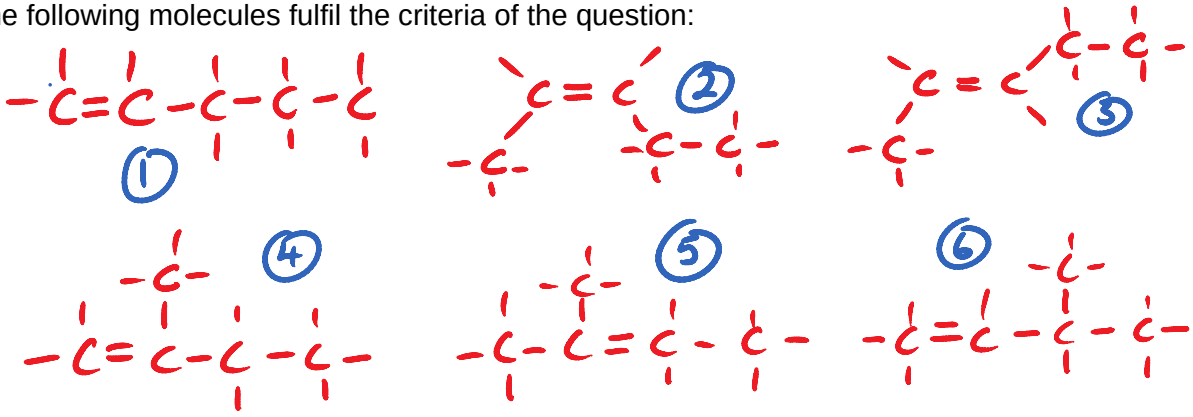
green sp^3



Compound **K**

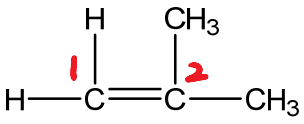
Ans: A

18 The following molecules fulfil the criteria of the question:



Ans: C

19



2-methylpropene

The reactant is bromine, so Br would enter first and attached itself to carbon (1) due to Markonikov's rule. Then, since there is large concentration of bromide (Br^-) ions mainly due to the concentrated NaBr, the Br^- will then attached itself to carbon (2).

Hence the major product is bromine attaching to both C across the double bond. **Ans: A**

20. **A** It has two times more sigma bonds than pi bonds.

Benzene has 3 pi bonds and 12 sigma bonds and hence the sigma bonds is 4 times more than the pi bond and hence false. **(Ans)**

B The C and the H atoms in benzene are all on the same plane.

Benzene is a planar molecule with each carbon being sp^2 hybridized. Hence all the C and H atoms are on the same plane.

C It has 6 pi electrons in its ring of delocalised electrons.

Each C atom contribute one electron to the ring of delocalised electron giving rise to 6 electrons to the ring.

D It is less reactive compared to alkenes.

The ring of delocalised electrons help to stabilize benzene to make it less reactive than an alkene.

21 The rate of hydrolysis depends on the strength of the C-X(halogen) bond. When X is a C*l* atom, the C-X bond is the strongest and hence would be the slowest to precipitate. However, option D shows that the I is directly attached to the benzene ring, which is stronger than any aliphatic C-X bond as the lone pair on the halogen can delocalise into the benzene ring. Thus D would be the slowest to show the appearance of a ppt

Ans: D

22 **A** Concentrated H_2SO_4, 170˚C

Will dehydrate both alcohols to form alkene.

B $Cr_2O_7^{2-}$, H_2SO_4 (aq), heat

Will only react with the alcohol to the right of benzene as it's a secondary alcohol but not the left one as the left one is a tertiary alcohol **(Ans)**

C I_2 dissolved in NaOH (aq), warm

Will not react with both as they both are not methyl alcohols.

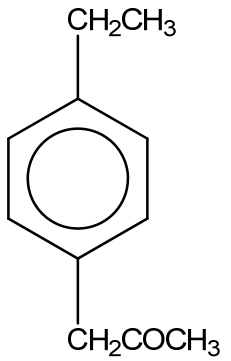
D P*Cl*$_5$ at r.t.p

Wil react with both to substitute OH with C*l*.

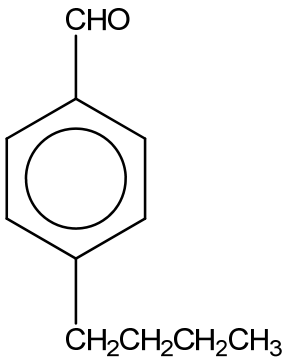
23

- Gives an orange precipitate with 2,4-dinitrophenylhydrazine (Criteria 1)
- Yields 1,4-dibenzoic acid when reacted with acidified $KMnO_4$ (Criteria 2)
- Unable to react with Fehling's solution but able to react with Tollen's reagent (Criteria 3)

A



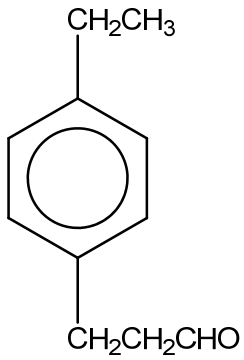
C



Unable to fulfil criteria 3 as it does not have a benzaldehyde

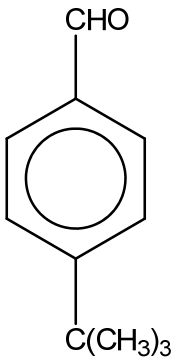
Able to fulfil all 3 criteria **(Ans)**

B



Unable to fulfil criteria 3 as it would react with Fehling's given that it has an aliphatic aldehyde

D



Unable to fulfil criteria 2 as the alkyl group below does not have a H directly attached to the C attached to benzene.

24 Smallest pK_a value implies a large K_a value and hence he strongest acid among the 4 options

$CH_3CH(NH_2)CH_2COOH$

A N is less electronegative than O and hence it is less able to disperse the negative charge on the conjugate base of the acid and hence less acidic

B $CH_3CH(OH)CH_2COOH$

Though it has an O atom that is more electronegative than N thus helping to better disperse the negative charge on the conjugate base, but when compared to D, the OH group is further away from the COOH group making it disperse the negative charge less effectively than D, making it a weaker acid when compared to D

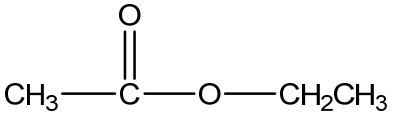
C $CH_3CH_2CH(NH_2)COOH$

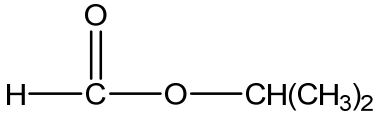
N is less electronegative than O and hence it is less able to disperse the negative charge on the conjugate base of the acid and hence less acidic

D $CH_3CH_2CH(OH)COOH$

It is the strongest acid as it has the O atom which is more electronegative than N and it is closest to the COOH group hence able to disperse the negative charge on the conjugate base the most effectively among the 4 options **(Ans)**

25 Below are the structures of two ester isomers with the molecular formula $C_4H_8O_2$.





Which of the following reagents can be used to distinguish these 2 ester isomers?

A $Cr_2O_7^{2-}$, H_2SO_4 (aq), heat

The acid and heat will hydrolyse both esters and the oxidising agent will oxidise both the alcohols produced from the hydrolysis hence not able to distinguish.

B MnO_4^-, H_2SO_4 (aq), heat

The acid and heat will hydrolyse both esters and the oxidising agent will oxidise both the alcohols produced from the hydrolysis. However, the acid produced from the hydrolysis of the ester on the right is methanoic acid which can also be oxidise to produced CO_2 gas and hence able to distinguish the 2 esters. **(Ans)**

C Li*Al*H_4 in dry ether

Able to reduce both esters and hence not able to distinguish

D 2,4 dinitrophenylhydrazine

Not able to react with either of the esters and both do not contain a carbonyl group.

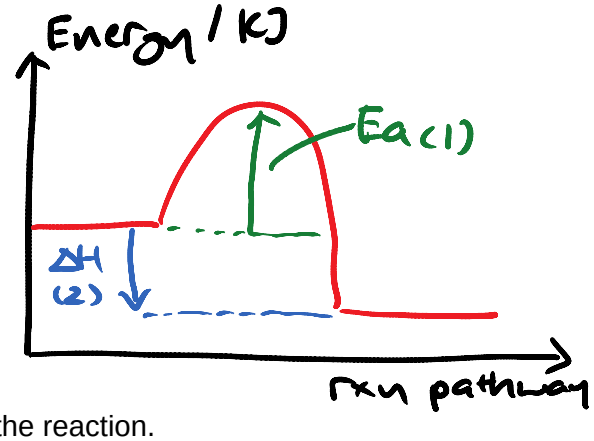
26 **1** Cr (6), Co^{3+}(4)

2 Fe^{2+}(4), Mn^{3+}(4)

3 Cu^{+}(0), V^{5+}(0)

Ans: C (2 & 3)

27 **1** The activation energy of the reaction.



2 The enthalpy change of the reaction.

3 The number of steps in the mechanism of the reaction.

Each peak in the reaction pathway diagram represents a step and hence number of peaks give you the number of steps in the mechanism.

Ans: A (1, 2 & 3)

28 **1** 25 cm^3 of 0.100 mol dm^{-3} HC*l* and 15 cm^3 of 0.100 mol dm^{-3} NH_3

Excess strong acid (HC*l*) and salt; hence not a buffer

2 25 cm^3 of 0.100 mol dm^{-3} NH_3 and 10 cm^3 of 0.100 mol dm^{-3} H_2SO_4

Excess weak base (NH_3) and salt of a weak base; hence a buffer

3 25 cm^3 of 0.100 mol dm^{-3} CH_3COOH and 15 cm^3 of 0.100 mol dm^{-3} NaOH

Excess weak acid (CH_3COOH) and salt of a weak acid; hence a buffer

Ans: C (2 & 3)

29 The products of oxidation of compound **M are**

The compounds formed only contain carbonyl compounds. No acids or carbon dioxide present.

Ans: D (1 only)

30 Condensation is a reaction that combines 2 molecules together to form 1 with the displacement of a small molecule (e.g. H_2O or HC*l*)

1 The reaction between an acid chloride and alcohol forms an ester and water.
Condensation

2 The reaction between a carbonyl compound and 2,4-dinitrophenylhydrazine forms an orange precipitate and water.
Condensation

3 The reaction between an alcohol and concentrated sulfuric acid at 170˚C forms an alkene and water.
Elimination

Ans: B (1 & 2)