JC2 Prelims 2009 H2 Chemistry (Paper 1) Worked Solutions

1. Ans: A

 $MO + H_2SO_4 \rightarrow MSO_4 + H_2O$

 $H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O$

No. of moles of $H_2SO_4 = \frac{100}{1000} \times 1$

No. of moles of excess $H_2SO_4 = \frac{1}{2} \times No.$ of moles of NaOH

$$= \frac{1}{2} \times \frac{21.45}{1000} \times 1$$

= 0.0107 mol

No of moles of H_2SO_4 reacted with MO = no. of moles of MO

=0.0892 mol

- $M_r \text{ of MO} = \frac{5.0}{0.0892}$ = 56.0 $A_r \text{ of M} = 40.0$
- 2. Ans: C

Let the volume of CH_4 be *x*.

Then the volume of $C_2H_6 = 70-x$

Volume of carbon dioxide gas formed in total = x + 2(70-x)

Change in volume of residual gases after passing through NaOH

= volume of carbon dioxide formed

= 130 -35

Hecne, 140- x = 95

 $x = 45 \text{ cm}^3$

Volume of methane = 45 cm^3 ; volume of ethane = 25 cm^3

3. Ans: C

A: Si: [Ne] 3s² 3p²

2 unpaired electrons in the 3p orbital

B: S [Ne] 3s² 3p⁴

3 unpaired electrons in the 3p orbital

C: Fe²⁺ : [Ar]3d⁶

4 unpaired electrons in the 3d orbital

D: Cr³⁺: [Ar]3d³

3 unpaired electrons in the 3d orbital

4. Ans: B

Element X is in Group III while element Y is in Group VI. Hence the formula formed between X and Y is X_2Y_3 .

5. Ans: C

 NO_2 , SO_2 are simple covalent molecules with weak van der Waals forces, while water, also a simple molecule, has hydrogen bonding. SiO_2 is a giant covalent molecule with strong covalent bonds between Si and O atoms, hence it requires the largest amount of energy to overcome the strong covalent bonds. Hence, it has the highest energy.

6. Ans: A

In ice, each water molecule is hydrogen-bonded to four other water molecules, in a tetrahedral arrangement, hence having a bond angle of 109.5°.

7. Ans: B

no. of moles of gas in small spacecraft =
$$\frac{pV}{RT} = \frac{(40)(20)}{RT} = \frac{800}{RT}$$

no. of moles of gas in large spacecraft = $\frac{pV}{RT} = \frac{(150)(50)}{RT} = \frac{7500}{RT}$
total no. of moles of gas = $\frac{800 + 7500}{RT} = \frac{8300}{RT}$
Pressure in the combined arrangement = $\frac{nRT}{V} = \frac{(8300/RT)RT}{(20+50)} = 119atm$

8. Ans: D

 $pV=nRT \rightarrow V = \frac{nRT}{p}$

when the mass is fixed, n is constant. when pressure is constant, V is proportional to T in Kelvin. Since the x-axis shown is T in $^{\circ}$ C, the straight line should cut the x-axis at -273

9. Ans: C

Q=mc T = (25+25)(4.2)(20) no. of mol of H₂O formed = 0.04 numerical value of H = $\frac{Q}{0.04} = \frac{50 \times 4.2 \times 20}{0.04}$

10. Ans: C

H O H → 2H (g) + 2O(g) H_{atm} = energy required to break 2 O-H bonds and 1 O-O bond = + (2)(460) + 150 = +1070 kJ mol⁻¹

11. Ans: A

Students need to balance their own half equation as follows: $MnO_{4}^{-} + e \rightarrow MnO_{4}^{2-}$ $H_{2}O + HCOO^{-} \rightarrow CO_{3}^{2-} + 3H^{+} + 2e$ $\frac{nMnO_{4}^{-}}{nHCOO^{-}} = \frac{2}{1} = \frac{5x10^{-4}}{2.5x10^{-4}}$ Since, volume = $\frac{number \text{ of moles}}{concentration} = \frac{2.5x10^{-4}}{0.05} = 5cm^{3}$

12. Ans: B

Ni²⁺ + 2e →Ni E°= -0.25 V

Since Nickel can only be oxidized, species A - D can only be reduced. Hence, Options C and D is eliminated as Cu and C*I* cannot be reduced.

Option A:

 $Cr^{3+} + e \rightarrow Cr^{2+}$ E^o= -0.41 V is chosen over

 $Cr^{3+} + e \rightarrow Cr$ $E^{\circ} = -0.74$ V as a more positive reduction potential indicates that preferred reduction.

 $\begin{array}{ll} Cr^{3^{+}} + e \rightarrow Cr^{2^{+}} & E^{\circ} = -0.41 \ V \\ Ni^{2^{+}} + 2e \rightarrow Ni & E^{\circ} = -0.25 \ V \\ E^{\circ} \ \text{overall} = -0.41 - (-0.25) = -0.16 \ V \ (\text{not feasible}) \\ \hline \textbf{Option B:} \\ Pb^{2^{+}} + 2e \rightarrow Pb & E^{\circ} = -0.13 \ V \\ Ni^{2^{+}} + 2e \rightarrow Ni & E^{\circ} = -0.25 \ V \\ E^{\circ} \ \text{overall} = -0.13 - (-0.25) = +0.12 \ V \ (\text{feasible}) \end{array}$

13. Ans: A

	P (g)	Q(g)	R (g)
Initial	0.50	0.50	0
Change	-0.15	-0.15	+0.45
Equilibrium	0.35	0.35	+0.45

$$Kc = \frac{\left(\frac{0.45}{2}\right)^3}{\left(\frac{0.35}{2}\right)^2} = 0.372$$

14. Ans: C

	Condition	Position of	Kp	Rate of forward
	Increase in	Right (False)	Increase (False)	Increase (True)
A	temperature	Position of eam will	$Kn = k_f / k_h$	Rate of forward and rate
	to the post of the second	shift to favour the	Hence, backward rate	of backward both
		endothermic side	constant will increase	increases. However.
		which is the left hand	more than the rate	backward rate will
		side.	forward constant.	increase more than the
			Hence Kp should	rate forward.
			decrease.	
	Addition of	No change (True)	No change (True)	No change (False)
в	catalyst	Rate of forward and	Kp is independent of	Rate of forward and
		backward inceases by	catalyst and	backward increases by
		the same amount.	dependant only on	the same amount.
		Hence eqm position	Temperature.	
		does not change.		
	Decrease in	Left (True)	No change (True)	Decrease (True)
	pressure	Position of eqm will	Kp is independent of	Rate of forward and rate
		shift to favour the	pressure and	of backward both
С		side with lesser no. of	dependant only on	decreases by the same
		moles of gaseous	Temperature.	amount. Decrease in
		molecules which is		pressure infers lesser no.
		the left hand side.		of effective collisions.
	Addition of H_2	Right (True)	Increase (False)	Increase (True)
D	(g)	Position of eqm will	Kp is independent of	Rate of forward
		shift to favour the	concentration and	increases as more
		side with no	dependant only on	hydrogen inters more
		hydrogen which is	Temperature.	no. of effective
		the right hand side.		collisions.

15. Ans: C

Ksp = $[Ag^+][OH^-] = 1.52 \times 10^{-8} \text{ mol}^2\text{dm}^{-6}$ Hence at equilibrium, $[OH^-]^2 = 1.52 \times 10^{-8} \text{ mol}^2\text{dm}^{-6}$ $[OH^-] = (1.52 \times 10^{-8})^{1/2} = 1.23 \times 10^{-4}$ pOH = 3.90 pH = 14 - 3.90 = 10.1

16. Ans: B

8.2 g of sodium ethanoate = 0.1 mol [sodium ethanoate] = [salt] = 0.2 mol dm⁻³ $K_a = K_w / K_b = 1.75 \times 10^{-5}$ pH = pKa + lg ([salt] / [acid]) = -lg(1.75 x 10⁻⁵) + lg ((0.2) / (0.1)) = 5.06

17. Ans: B

No. of counts per minute is proportionate to the concentration of the radioactive substance.

 $\left(\frac{C_f}{C_o}\right) = \left(\frac{1}{2}\right)^n$ where n is the number of half-lives and C_f is the no. of counts per minute for

the final product, C_{o} is the no. of counts per minute for the initial substance.

n = 0.58496

therefore the age of the ship is n x $t_{\mbox{\tiny 12}}$ = 3276 years

18. Ans: D

Base on experiments 2 and 3, 2^{nd} order with respect to [R] Base on experiments 1 and 2, and that it is 2^{nd} order with respect to [R], 0^{th} order with respect to [Q] Rate's unit is mol dm⁻³ s⁻¹ Therefore units of k, rate constant, is mol⁻¹ dm³ s⁻¹

19. Ans: B

- electrical conductivity would increase first and then decrease
- bonding with oxides does change from ionic to covalent
- melting point of the oxides would increase first and then decrease
- electronegativity of the element would increase across the period

20. Ans: A

- Na would combust to form Na₂O, which would produce an alkali, NaOH, when dissolved in water
- Al would combust to form Al₂O₃, which is insoluble in water, resulting in a neutral solution
- S would combust to form SO₂, which would produce an acid, H₂SO₃, when dissolved in water
- P would combust to form P₄O₁₀, which would produce an acid, H₃PO₄, when dissolved in water

21. Ans: A

Lattice energy is always negative. Down the group, the magnitude of the lattice energy decreases due to greater cationic radius. Lattice energy becomes less exothermic down the group. The enthalpy change of hydration is the sum of hydration energy of the cation and anion. The difference lies in the cations. Down the group, the charge density decreases as size increases. Therefore, the hydration energy becomes less exothermic.

22. Ans: C

Heterogeneous catalyst works by the availability of the 3d and 4s electrons to allow ready exchange of electrons between the transition metal catalyst and the reactant molecules to form weak bond.

23. Ans: A

 CH_3CH_2Cl can undergo nucleophilic substitution to give CH_3CH_2CN while $CH_3COCH_2CH_3$ can undergo nucleophilic addition to give $CH_3CCN(OH)CH_2CH_3$. In option B, esters do not undergo nucleophilic reactions. In option C, aryl halides cannot undergo nucleophilic substitution as the C- Cl bond is strong due to overlap of p orbitals. In option D, both the aryl halides and ester bonds are present.

24. Ans: B

Tertiary alcohol reacts with thionyl chloride(SOCl₂) to give



Option A is invalid as there are no optical and geometric isomers. Option C is invalid as there is no possible functional groups for oxidation. Alcohol group present is tertiary. Option D is also invalid as there are no ketones or aldehyde groups for 2,4 DNPH to react.

25. Ans: B

Only Na and NaOH can react with phenol to give a phenoxide. Option A is wrong. The phenoxide ion can act as a nucleophile and only CH_2C/CH_2COOH can react to give the correct structure via a nucleophilic substitution reaction. Reagent in Step II of option C is an alcohol an does not react while the reagent in Step II of option D will give a product with an extra CH_2 .

26. Ans: D

Electorphilic addition takes place between bromine and propene.

Hence, Br atom will enter first resulting in a carbocation.

However, comparing the strength of the 3 anions left, ONO_3^- , OH^- and Br^- , ONO_3^- and OH^- are much stronger due to their high concentration.

Therefore, the major product would be with 1 Br added to 1 of the carbon atoms about the C=C double bond with ONO_3^- and OH^- added about the other carbon atom.

27. Ans: A

A:

The compound contains 2 benzaldehyde groups which does not react Fehling's solution

B:

Under heat, acidified KMnO₄ will cleave the double bond while the acid in the reagent will hydrolyze the esters , resulting in a dicarboxylic acid

C:

Sulfuric acid will hydrolyze both the CN and ester groups to carboxylic acids resulting in the dicarboxylic acid

D:

lodoform will react with both the methyl alcohol and methyl ketone side-chains to carboxylic acids resulting in the dicarboxylic acid.

28. Ans: B

Lead from the leaded petrol will "poison" the catalytic converter by coating itself on the platinum and rhodium catalyst, destroying them and rendering them useless.

29. Ans: A

Since the requirement of the question is to form a peptide linkage, the linkage can only be formed between the NH_2 and COOH groups on the alpha carbon (i.e. the carbon atom with both the NH_2 and COOH group attached to it).

Therefore, the possible combinations would be EITHER between the NH_2 group on the alpha carbon from lysine with the COOH group on the alpha carbon on glutamine OR between the NH_2 group on the alpha carbon from glutamine with the COOH group on the alpha carbon on lysine,

30. Ans: D

A and B:

Both are able to form zwitterions but there are no chiral carbons present.

C:

Unable to form zwitterions

D:

The only molecule among the 4 choices that can both form a zwitterions and contains a chiral carbon.

31. Ans: B



Thus, 1 and 2 only

32. Ans: D

 ΔH°_{f} : Enthalpy change when 1 mole of a pure compound is formed from its elements with all substances in their standard states and conditions.

 ΔH_c : Heat evolved when 1 mol of a substance is completely burnt in oxygen (ΔH_c is applied to measurements of heat change being adjusted to standard conditions.)

Option 1: C(s) + O₂ (g) \rightarrow CO₂(g) = $\Delta H^{\circ}_{f (carbon)} / \Delta H^{\circ}_{c (carbon)}$

Option 2: H₂O is not in standard state.

Option 3: CO(g) + $\frac{1}{2}O_2(g) \rightarrow CO_2(g) = \Delta H^\circ_{c(CO)}$ but not ΔH°_f since CO₂ is not formed from C(s).

Thus, only 1.

33. Ans: D

 $MnO_4^{-} + 8H^{+} + 5e^{-}$ $Mn^{2+} + 4H_2O$

E^θ= +1.52V

Option 1: $SO_4^{2-} \rightarrow S_2O_8^{2-} + 2e$ $E^{\theta} = +2.01V$ $E^{\theta}_{\text{overall}} < 0$ Hence SO_4^{2-} will not be oxidized by MnO_4^{-} and can be used to provide the acidic condition.

Option 2: $2CI^{-}(aq)$ \sim $CI_{2}(g)$ + 2e E^{θ} = +1.36 V

 $E^{\theta}_{overall} > 0$ Hence Cl⁻ will be oxidized by MnO₄⁻

Option 3: Ethanedioic acid will be oxidized to CO₂

Thus only 1.

34 Ans: C

Option 1: False. The pH at equivalence point should be < 7 since the salt is acidic.

Option 2: At point B, there is NH_3 (weak base) and salt present. Hence it is a buffer solution.

Option 3: At point A, only NH₃ (weak base) is present. Hence, $K_{b} = [OH^{-}]^{2}/[NH_{3}] = (10^{-2.9})^{2}/0.1 = 1.58 \times 10^{-5} \text{ mol dm}^{-3}$

Thus, only 2 and 3.

35. Ans: B

Option 1: Based on the slow step, 1 mol of H_2O_2 reacts with 1 mol of I⁻. Hence reaction is first order w.r.t to both reactants.

Option 2: O.N of O in H_2O_2 is -1.

O.N of O in H_2O is -2.

Since there is a decrease in O.N for O, therefore hydrogen peroxide is reduced.

Option 3: H^+ is consumed but not regenerated in the reaction. Hence it cannot be the catalyst.

Thus, only 1 and 2

36 Ans: B

NaAt reacts with AgNO₃ to form a ppt of AgAt. Down the group, K_{sp} of AgX decrease. AgAt is insoluble in aq NH₃ as its ionic product is not lower than its very low K_{sp} .

Down the group, X_2 becomes weaker oxidizing agents. At₂ is the weakest oxidizing agent in Group VII.

Boiling point of X_2 increases down the group due to increased number of electrons. Hence volatility of X_2 decreases. If I_2 is a solid, so is $At_2!$

Thus, only 1 and 2

37 Ans: A

Neutral FeCl₃ gives a purple colouration with phenolic compound, that is thyroxine but not with cyproterone.

Alkaline aq I_2 gives a yellow ppt with alcohols with CH_3CHOH - or ketones or aldehydes with CH_3CO -, hence cyproterone (with CH_3CO -) will give a yellow ppt with iodoform test while thyroxine will not.

 Na_2CO_3 gives effervescence of CO_2 with carboxylic acid, hence thyroxine will give a positive test while cyproterone will not.

Thus, 1, 2 and 3

38 Ans: C

Delocalised electrons cause benzene ring to attract positively charged electrophile, not nucleophile.

The delocalization of electrons causes Benzene to have intermediate character between C-C and C=C bonds.

Benzene does not undergo addition reactions in order to retain its stability due to delocalized electrons. Substitution will not cause the loss of its delocalized structure. Thus only 2 and 3

39 Ans: A

With excess conc. H_2SO_4 at 170°C, propan-1-ol undergoes intramoleulcar dehydration to give alkene, $CH_3CH=CH_2$.

With excess propanol or limited conc. H_2SO_4 at 140°C, propan-1-ol undergoes intermolecular dehydration to give ether, $CH_3CH_2CH_2OCH_2CH_2CH_3$.

Propanol undergoes dehydration with conc H_2SO_4 to form alkene, which with cold conc. H_2SO_4 , undergoes electrophilic addition giving $CH_3CH_2CH_2OSO_3H$ even though product formed is the minor product.

Thus, 1,2 and 3

40 Ans: A

 \mathbf{Q} has C_xH_{2x} formula, it must be an alkene or a cyclic alkane.

Since it is oxidisable by MnO_4^-/H^+ , it must be an alkene with C=C cleaved during oxidation.

R gives yellow ppt with iodoform test, hence it must be a ketone with CH_3CO - group (alcohol with CH_3CHOH - is not possible as **R** is a product of oxidation.)

S forms CO_2 with Na_2CO_3 , hence it must contain COOH.

Since **Q** contains C=C, it will decolourise aq Br_2 as it undergoes electrophilic addition.

Since R is a ketone, it will give orange ppt with 2,4-DNPH

S contains COOH, it will form HCl white fumes with PCI_5 .

Thus, 1, 2 and 3