# Detailed Answers for H1 Chemistry Prelim Paper 2009

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

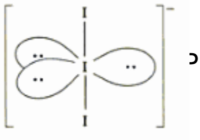
**1** **A Correct:** 1 mole of methane contains 4 moles of H atoms = 4 x 6.02 x $10^{23}$
= 2.41 x $10^{24}$ H atoms.
**B Correct:** Ar of $^{12}C$ is 12.0.
**C Wrong:** One mole of hydrogen gas contains 2 moles of hydrogen atoms = **2 x** 6.02 x $10^{23}$ atoms of hydrogen.
**D Correct:** One mole of methane (16.0g) contains one mole of carbon (12.0g) $\frac{12.0}{16.0}\times 100\% = 75\%$
Answer: **C**

**2** This is a disproportionation reaction where $Cu_2O$ is reduced to Cu and is oxidised to $CuSO_4$ simultaneously. Hence, it can act as both an oxidising and reducing agent. $H_2SO_4$ is not reduced or oxidised in this reaction.
Answer: **A**

**3** Let the oxidation state of Fe in $[Fe(CN)_6]^{4-}$ be $x$.
$x + 6(-1) = -4$
$x = +2$
Electronic configuration of Fe is $[Ar]3d^64s^2$.
Electronic configuration of $Fe^{2+}$ is $[Ar]3d^6$.
Answer: **A**

**4** The state of a compound depends on its bonding. $CO_2$ gas is made up of simple molecule with weak dispersion forces (a type of van der Waals' forces) of attraction between the molecules. $SiO_2$ has strong covalent bonds throughout the giant molecular structure. Therefore, more energy is required to overcome the strong covalent bonds in $SiO_2$ compared to the weak dispersion forces in $CO_2$ gas. The boiling point of $SiO_2$ is much higher than $CO_2$, therefore it is a solid at r.t.
Answer: **B**

**5** **A** $CO_2$ is linear (0 lp, 2 bp); $SO_2$ is bent (1 lp, 2 bp)
**B** $NH_3$ is trigonal pyramidal (1 lp, 3 bp); $NO_3^-$ is trigonal planar (0 lp, 3 bp)
**C** $CO_2$ is linear (0 lp, 2 bp); $I_3^-$ is linear (3 lp, 2 bp).The linear shape of $I_3^-$ is due to 3 lp occupying the equatorial positions in a trigonal pyramid.



**D** $BCl_3$ is trigonal plan PC$l_3$ is trigonal pyramidal (1 lp, 3 bp
Answer: **C**

**6** The standard enthalpy change of formation is when **one mole** of a pure compound is **formed** from its **constituent elements** in their **standard states**, under standard conditions of 298K and 1 atm.
Answer: **B**

**7** $\Delta H_c\,(C_3H_4) = \sum \Delta H_{f\,(product)} - \sum \Delta H_{f\,(reactant)}$
$-1938 = (-394 \times 3) + (-286 \times 2) - \Delta H_f\,(C_3H_4)$
$\Delta H_f\,(C_3H_4) =$ **+ 184 kJ $mol^{-1}$**
Answer: **A**

**8** For $C_2H_6(g) \rightleftharpoons C_2H_4(g) + H_2(g)$,
$\Delta H_{rxn}$ = Total bond energy for reactants – Total bond energy for products
= [BE(C-C) + 6BE(C-H)] – [BE(H-H) + BE(C=C) + 4BE(C-H)]
= [350 + 6(410)] – [436 +610 + 4(410)]
= +124 kJ $mol^{-1}$ > 0
When temp increases, position of eqm shifts left to counteract the increase in temp, hence, eqm yield of ethene decreases. Rate of formation of ethene will decrease at lower temperature due to smaller frequency of collision between reactants molecules to form the products.
Answer: **B**

**9** **A** $K_c = \frac{[H_2][CO]}{[H_2O]}$ **Unit:** mol $dm^{-3}$

**B** $K_c = \frac{[Cu(NH_3)_4^{\ 2+}]}{[Cu^{2+}][NH_3]^4}$ **Unit:** (mol $dm^{-3})^{-4}$

**C** $K_c = \frac{[NO_2]^2}{[N_2O_4]}$ **Unit:** mol $dm^{-3}$

**D** $K_c = \frac{[CH_3CO_2CH_3][H_2O]}{[CH_3OH][CH_3CO_2H]}$ **Unit:** -

Answer: **D**

**10** **A** Ammonia acts as a proton acceptor (a base).
**B** Ammonia acts as a ligand to form the complex ion.
**C** Ammonia acts as a proton donor (an acid). Acid-metal reaction gives salt and hydrogen gas.
**D** Ammonia acts as a nucleophile or a Lewis base (electron pair donor).
Answer: **C**

**11** pH = 2.0 means that $[H^+] = 10^{-2}$ mol $dm^{-3}$, and no. of moles of $H^+ = 2.0 \times 10^{-2}$
Upon dilution, no. of moles of $H^+$ remains unchanged at $2.0 \times 10^{-2}$. But, new pH = 3.0 means that new $[H^+] = 10^{-3}$ mol $dm^{-3}$
Let v = vol. of water added. Hence,
new $[H^+] = 10^{-3}$ mol $dm^{-3} = 2.0 \times 10^{-2} / (2.0 + v)$
v = vol. of water added= 18 $dm^3$
Answer: **C**

**12** $HCO_3^{2-}$ being the acid, removes the small amt of base added.
$$HCO_3^- + OH^- \rightarrow CO_3^{2-} + H_2O$$
$CO_3^{2-}$ being the conjugate base of $HCO_3^-$, removes the small amt of acid added.
$$CO_3^{2-} + H_3O^+ \rightarrow HCO_3^- + H_2O$$

**13** Rate $\alpha \frac{1}{t} \Rightarrow$ Rate = $\frac{x_1}{t}$

When the $[S_2O_8^{2-}]$ is halved, the initial rate is halved. Hence, the reaction is first order with respect to $S_2O_8^{2-}$.

When the $[I^-]$ is decreases by 3 times, the initial reaction is decreased by 3 times. Hence, the reaction is first order with respect to $I^-$.

Rate = $k[S_2O_8^{2-}][I^-]$

Answer: **D**

**14** For [Z] against time graph, a straight line means that it is zero order wrt Z since the rate of rxn remains unchanged with changing [Z].

For [X] against time graph, for [Y] = 2 mol $dm^{-3}$, a constant $t_{1/2}$ of 0.7 min means it is first order wrt X.

Let Rate= $k[X][Y]^a$

For [Z] against time graph, when [Y] is 2x,

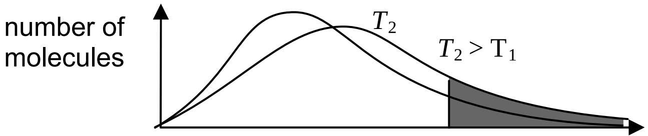
$(1/2)^a = (0.02/0.08)$

$a = 2$

Hence, Rate= $k[X][Y]^2$, for [X] is halved and [Y] is doubled, new rate is increased by $(1/2)(2)^2 = 2$ times.

Answer: **B**

**15**



According to Maxwell-Boltzmann distribution curve, the number of molecules with kinetic energy greater than the activation energy is greater at a higher temperature. With increased kinetic energy, the frequency of effective collisions between molecules with kinetic energy greater than the activation energy is greater at a higher temperature.

Answer: **C**

**16** X is Al since $Al_2O_3$ has a giant ionic structure while $AlCl_3$ has a simple molecular structure.

- **A** The melting pt of MgO is the highest (higher than that of $Al_2O_3$) among all the oxides of Period 3 elements.
- **B** $X^{2+}(g) \rightarrow X^{3+}(g) + e$, 3rd IE and $Na^+(g) \rightarrow Na^{2+}(g) + e$, 2nd IE
  Since $[X^{2+}] = [Na^+] = 1s^22s^22p^6$, 3rd IE of X = 2nd IE of Na.
- **C** $AlCl_3$ undergoes hydrolysis in water to give rise to an acidic solution:
  $[Al(H_2O)_6]^{3+} + H_2O \rightleftharpoons [Al(H_2O)_6(OH)]^{2+} + H_3O^+$
  $H_2$ gas is evolved from acid-base reaction:
  $2H^+ + Mg \rightarrow Mg^{2+} + H_2$
- **D** $Al_2O_3 + 2KOH + 3H_2O \rightarrow 2KAl(OH)_4$

Answer: **A**

**17** Outermost shell electronic configuration of M (P) is $3s^23p^3$.

Outermost shell electronic configuration of N (S) is $3s^23p^4$.

Hence, less energy is required to remove an electron from paired 3p electrons in S due to interelectronic repulsion. 1st IE of M is > 1st IE of N.

For ionic radius of L ($Al^{3+}$), it only has two quantum shell comparing to the three quantum shells which M (P) has, hence, L has a smaller ionic radius than M.

**18**
**A** ketone is reduced to 2° alcohol. Hydride behaves as RA.
**B** $H^-$ is not able to eliminate hydrogen from ethane.
**C** aldehyde is reduced to 1° alcohol. Hydride behaves as RA.
**D** ethanoic acid is neutralized to form ethanoate ion. Hydride behaves as a base.

Answer: **B**

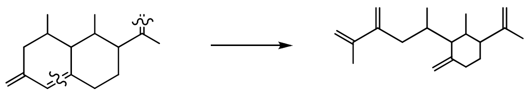
**19**
**A** 2 mono-sub products formed
$\Rightarrow$ 1-chloro-2-methylpropane and 2-chloro-2methylpropane.
**B** 4 mono-sub products formed
$\Rightarrow$ 1-chloro-3-methylpentane, 2-chloro-3-methylpentane, 3-chloro-3-methylpentane and 3-(chloromethyl)pentane
**C** 2 mono-sub products formed
$\Rightarrow$ 1-chloro-2,3-dimethylbutane and 2-chloro-2,3-dimethylbutane
**D** Symmetrical 2,2-dimethylpropane yields **only one** mono-sub product $\Rightarrow$ 1-chloro-2,2-dimethylpropane.

Answer: **D**

**20**
**A** Methylbenzene can be oxidized to benzoic acid by hot $KMnO_4/H^+$
**B** methylbenzene + conc $H_2SO_4$ + Conc $HNO_3$ will yield 2-nitomethylbenzene since $-CH_3$ is ortho,para directing,
**C** It undergoes side-chain free radical substitution with $Br_2$ to form (bromomethyl)benzene.
**D** $-CH_3$ is ortho, para directing, thus 3-bromomethylbenzene is cannot be made directly.

Answer: **D**

**21**
**A** Absence of $CH_3CO$— and $CH_3CH(OH)$— structures$\Rightarrow$ no yellow ppt with alkaline $I_2$.
**B** Absence of aldehyde group, no silver mirror formed.
**C** HCN(aq) with trace base react with ketone to form nitrile compound.
**D**



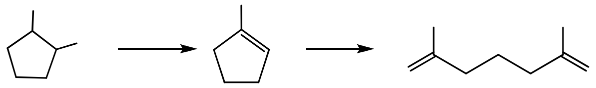
Answer: **D**

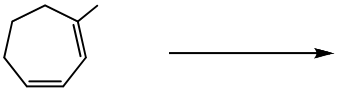
**22** Since the two substituents bonded to hydroxyl-containing carbon comes from Grignard reagents, the substituents must be $–CH_3$ and $-CH_2CH_3$ only. 4-ethylheptan-4-ol has substituent of $–CH_2CH_2CH_3$. Thus not possible to form.

Answer: **B**

**23** Which process will **not** give a good yield of $CH_3CO(CH_2)_3CO_2H$?

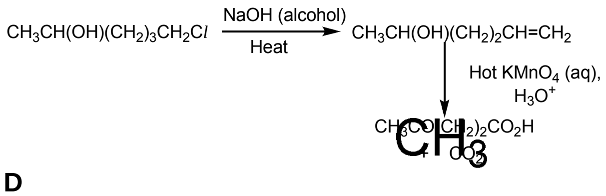
**A**





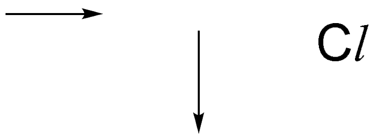
**B**

**C**



$CH_3CH(OH)(CH_2)_3CH_2Cl \xrightarrow[\text{Heat}]{\text{NaOH (alcohol)}} CH_3CH(OH)(CH_2)_2CH{=}CH_2$ $\xrightarrow{\text{Hot KMnO}_4\text{ (aq), H}_3\text{O}^+}$ $CH_3CO(CH_2)_2CO_2H + CO_2$

**D**



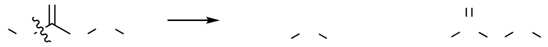
Answer: **C**

**24** Decolourises $Br_2$(aq) ⇒ presence of C=C bond.
Reacts with $PCl_5$ ⇒ presence of alcohol and carboxylic acid (-OH) functional groups.
Reacts with hot alkali to yield 2 alcohol groups ⇒ presence of (2 C-Hal bond) or (1 C-hal and 1 –OH)
Option **C** : The two –OH group on the same carbon will result in the elimination of $H_2O$ to form an aldehyde.
Answer: **A**

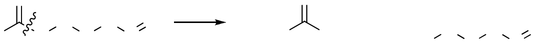
**25** Yellow precipitate with alkaline aqueous iodine ⇒

presence of and with molecular formula of $C_4H_8O_2$.

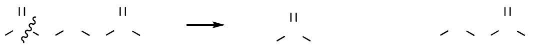
**A**



**B**



**C**



**D**

Answer: **C**

## Section B

**26** **1** $CH_3COOH$ is a weak acid and KOH is a strong base. Hence, a weak acid buffer of $CH_3COOH$ and its salt $CH_3COO^-K^+$ is formed.

**2** $NH_3$ is a weak base and $H_2SO_4$ is a strong acid. Hence, a weak base buffer of $NH_3$ and $(NH_4)_2SO_4$ is formed.

**3** $BaCl_2$ is a salt of the strong base $Ba(OH)_2$ but $Ba(OH)_2$ is a strong base, hence no buffer is formed.

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

**27** **1** Autocatalysis reaction involving $Mn^{2+}$ ions produced acting as a catalyst.

**2** This will not result in a sudden increase in rate as the solubility of $CO_2$ is very low.

**3** Concentrated sulfuric acid will act as dehydrating agent and not dilute sulfuric acid.

Answer: 1 only (**D**)

**28** T is in Group I since higher 2nd IE is required to remove the second e which is in the inner quantum shell.

$$T^+(g) \rightarrow T^{2+}(g) + e$$

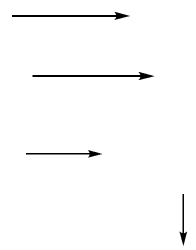
**1** since U is in Group II, size of T > size of U.

**2** W is in Group IV, chloride of W is $SiCl_4$.
Hence, the mixture is neutral.
$SiCl_4 + 2H_2O \rightarrow SiO_2 + 4HCl$
$Mg + 2HCl \rightarrow MgCl_2 + H_2$

**3** For 3, X is in Group IV, X= P. U is in Group II, U= Mg.
$P_4O_{10} + H_2O \rightarrow 4H_3PO_4$
$MgO + H_2O \rightarrow$ no reaction

Answer: **C**

**29** **1**



**2**

**3**

Answer: **1,2 and 3 (A)**

**30** **1** Test for –COOH function group

**2** 4 moles of $SOCl_2$ to react with 4 moles of –OH groups (from carboxylic acid and alcohol) per mole of pravastatin.

**3** 3 alcohol functional groups and 1 –COOH reacts with excess to give 2 moles of $H_2$ gas per mole of Pravastatin.

Answer: **1,2 and 3 (A)**