

JEE (MAIN) 2013 PAPER
Chemistry

This paper contains **30 multiple choice questions** and there is **only one** correct response for each question.

1. An unknown alcohol is treated with the "Lucas reagent" to determine whether the alcohol is primary, secondary or tertiary. Which alcohol reacts fastest and by what mechanism?
(A) Tertiary alcohol by S_N1 (B) Secondary alcohol by S_N2
(C) Tertiary alcohol by S_N2 (D) Secondary alcohol by S_N1

Solution

The reaction proceeds through S_N1 mechanism with tertiary alcohol and the rate of reaction is directly proportional to stability of carbocation formation. As tertiary carbocation formed by tertiary alcohol is highly stable, hence the reaction is the fastest.

Hence, the correct option is (A).

2. The first ionization potential of Na is 5.1 eV. The value of electron gain enthalpy of Na^+ will be
(A) - 5.1 eV (B) - 10.2 eV (C) + 2.55 eV (D) - 2.55 eV

Solution

The reaction involved is $Na \xrightleftharpoons[\Delta H = -5.1 \text{ eV}]{\Delta H = +5.1 \text{ eV}} Na^+ + e^-$. In this reaction, the backward reaction releases same amount of energy as the forward reaction and is known as electron gain enthalpy.

Hence, the correct option is (A).

3. Stability of the species Li_2 , Li_2^- and Li_2^+ increases in the order of
(A) $Li_2^- < Li_2^+ < Li_2$ (B) $Li_2 < Li_2^- < Li_2^+$
(C) $Li_2^- < Li_2 < Li_2^+$ (D) $Li_2^- < Li_2^+ < Li_2$

Solution

$$Li_2 (\text{atomic number} = 6) = \sigma 1s^2 \sigma^* 1s^2 \sigma 2s^2$$

$$\text{Bond order} = \frac{4 - 2}{2} = 1$$

$$Li_2^+ (\text{atomic number} = 6) = \sigma 1s^2 \sigma^* 1s^2 \sigma 2s^1$$

$$\text{Bond order} = \frac{3 - 2}{2} = 0.5$$

$$Li_2^- (\text{atomic number} = 7) = \sigma 1s^2 \sigma^* 1s^2 \sigma 2s^2 \sigma^* 2s^1$$

$$\text{Bond order} = \frac{4 - 3}{2} = 0.5$$

Li_2^+ is more stable than Li_2^- because Li_2^- has more numbers of antibonding electrons.

Hence, the order is $Li_2^- < Li_2^+ < Li_2$.

Hence, the correct option is (A).

4. The molarity of a solution obtained by mixing 750 mL of 0.5 (M) HCl with 250 mL of 2(M) HCl will be
(A) 1.00 M (B) 1.75 M
(C) 0.975 M (D) 0.875 M

Solution

$$M_1V_1 + M_2V_2 = MV$$

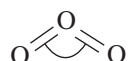
$$M = \frac{M_1V_1 + M_2V_2}{V} = \frac{0.5 \times 750 + 2 \times 250}{1000}$$

$$M = 0.875$$

Hence, the correct option is (D).

5. Which of the following is the wrong statement?
 (A) O_3 molecule is bent. (B) Ozone is violet-black in solid state.
 (C) Ozone is diamagnetic gas. (D) $ONCl$ and ONO^- are not isoelectronic.

Solution

(A) Correct, as  is bent.

(B) Correct, as ozone is violet-black solid in solid state.

(C) Correct, as ozone is a diamagnetic gas.

(D) Correct, as $ONCl$ contains 32 electrons and ONO^- contains 24 electrons. Hence they are not isoelectronic. Hence, all the options are correct.

Note: For this question, all four options are correct.

6. Four successive members of the first row transition elements are listed below with atomic numbers. Which one of them is expected to have the highest $E_{M^{3+}/M^{2+}}^0$ value?
 (A) Mn ($Z = 25$) (B) Fe ($Z = 26$) (C) Co ($Z = 27$) (D) Cr ($Z = 24$)

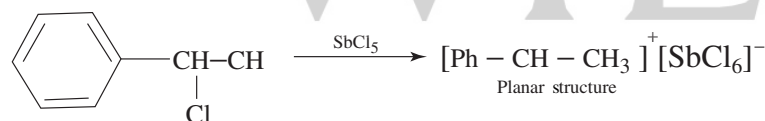
Solution

We know that $E_{Mn^{3+}/Mn^{2+}}^0 = 1.57 V$, $E_{Fe^{3+}/Fe^{2+}}^0 = 0.77 V$, $E_{Co^{3+}/Co^{2+}}^0 = 1.97 V$ and $E_{Cr^{3+}/Cr^{2+}}^0 = -0.41 V$.

Hence, the correct option is (C).

7. A solution of (–)-1-chloro-1-phenylethane is toluene racemizes slowly in the presence of a small amount of $SbCl_5$, due to the formation of

- (A) carbene (B) carbocation (C) free radical (D) carbanion

Solution

Hence, the correct option is (B).

8. The coagulating power of electrolytes having ions Na^+ , Al^{3+} and Ba^{2+} for arsenic sulphide sol increases in the order

- (A) $Na^+ < Ba^{2+} < Al^{3+}$ (B) $Ba^{2+} < Na^+ < Al^{3+}$
 (C) $Al^{3+} < Na^+ < Ba^{2+}$ (D) $Al^{3+} < Ba^{2+} < Na^+$

Solution

As_2S_3 is an anionic sol (negative sol). Hence coagulation will depend upon coagulating power of cation, which is directly proportional to the valency of cation (Hardy–Schulze rule).

Hence, the correct option is (A).

9. How many liters of water must be added to 1 liter of an aqueous solution of HCl with a pH of 1 to create an aqueous solution with pH of 2?

- (A) 0.9 L (B) 2.0 L (C) 9.0 L (D) 0.1 L

Solution

Initial pH = 1 $\Rightarrow [H^+] = 10^{-1} = 0.1 M$ and New pH = 2 $\Rightarrow [H^+] = 10^{-2} = 0.01 M$

In case of dilution, $M_1V_1 = M_2V_2$

$$0.1 \times 1 = 0.01 \times V_2 \Rightarrow V_2 = 10 L$$

Volume of water added = 9.0 L

Hence, the correct option is (C).

10. Which one of the following molecules is expected to exhibit diamagnetic behavior?
 (A) N_2 (B) O_2 (C) S_2 (D) C_2

Solution

N_2 and C_2 exhibit diamagnetic behavior, while O_2 and S_2 exhibit paramagnetic behavior.

Hence, the correct options are (A) and (D).

Note: For this question, two of the options are correct.

11. Which of the following arrangements does **not** represent the correct order of the property stated against it?
- (A) $Ni^{2+} < Co^{2+} < Fe^{2+} < Mn^{2+}$: ionic size
 (B) $Co^{3+} < Fe^{3+} < Cr^{3+} < Sc^{3+}$: stability in aqueous solution
 (C) $Sc < Ti < Cr < Mn$: number of oxidation states
 (D) $V^{2+} < Cr^{2+} < Mn^{2+} < Fe^{2+}$: paramagnetic behavior

Solution

Fe^{2+} contains four unpaired electrons as Cr^{2+} , whereas Mn^{2+} contains five unpaired electrons. The correct order should be $V^{2+} < Cr^{2+} = Fe^{2+} < Mn^{2+}$.

Hence (D) is incorrect.

12. Experimentally it was found that a metal oxide has formula $M_{0.98}O$. Metal M, is present as M^{2+} and M^{3+} in its oxide. Fraction of the metal which exists as M^{3+} would be
- (A) 4.08% (B) 6.05% (C) 5.08% (D) 7.01%

Solution

Given, metal oxide = $M_{0.98}O$. If x ions of M are in +3 state, then $3x + (0.98 - x) \times 2 = 2 \Rightarrow x = 0.04$.

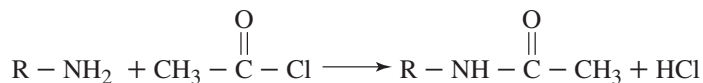
So, the percentage of metal in +3 state would be $\frac{0.04}{0.98} \times 100 = 4.08\%$

Hence, the correct option is (A).

13. A compound with molecular mass 180 is acylated with CH_3COCl to get a compound with molecular mass 390. The number of amino groups present per molecule of the former compound is
- (A) 5 (B) 4 (C) 6 (D) 2

Solution

The equation is



Addition of each molecule of CH_3CO- increases the molecular weight by 42.

Total increase in molecular weight = $390 - 180 = 210$

Then, number of NH_2 groups = $\frac{210}{42} = 5$

Hence, the correct option is (A).

14. Given $E_{Cr^{3+}/Cr}^{\circ} = -0.74 V$; $E_{MnO_4^-/Mn^{2+}}^{\circ} = 1.51 V$, $E_{Cr_2O_7^{2-}/Cr^{3+}}^{\circ} = 1.33 V$; $E_{Cl/Cl^-}^{\circ} = 1.36 V$

Based on the data given above, strongest oxidizing agent will be

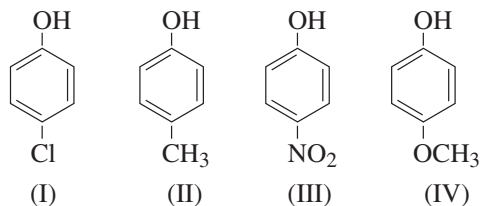
- (A) Cr^{3+} (B) Mn^{2+} (C) MnO_4^- (D) Cl^-

Solution

As per the data given, MnO_4^- is the strongest oxidizing agent as it has maximum standard reduction potential (SRP) value.

Hence, the correct option is (C).

15. Arrange the following compounds in order of decreasing acidity



- (A) I > II > III > IV (B) III > I > II > IV (C) IV > III > I > II (D) II > IV > I > III

Solution

Correct order of acidic strength is III > I > II > IV as the electron withdrawing group increases and electron releasing group decreases the acidic strength.

Hence, the correct option is (B).

16. The rate of a reaction doubles when its temperature changes from 300 K to 310 K. Activation energy of such a reaction will be ($R = 8.314 \text{ JK}^{-1} \text{ mol}^{-1}$ and $\log 2 = 0.301$)

- (A) 48.6 kJ mol⁻¹ (B) 58.5 kJ mol⁻¹ (C) 60.5 kJ mol⁻¹ (D) 53.6 kJ mol⁻¹

Solution

As per Arrhenius equation:

$$\ln \frac{k_2}{k_1} = -\frac{E_a}{R} \left(\frac{1}{T_2} - \frac{1}{T_1} \right)$$

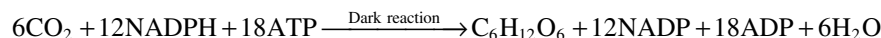
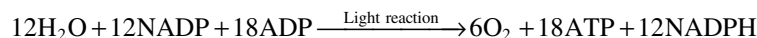
$$2.303 \log 2 = -\frac{E_a}{8.314} \left(\frac{1}{310} - \frac{1}{300} \right)$$

which gives. $E_a = 53.6 \text{ kJ mol}^{-1}$

Hence, the correct option is (D).

17. Synthesis of each molecule of glucose in photosynthesis involves

- (A) 10 molecules of ATP (B) 8 molecules of ATP
(C) 6 molecules of ATP (D) 18 molecules of ATP

Solution

The net reaction is $6\text{CO}_2 + 6\text{H}_2\text{O} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2$

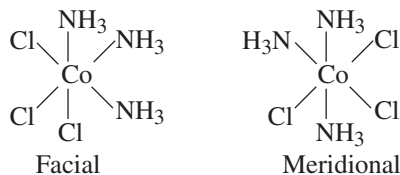
Hence, the correct option is (D).

18. Which of the following complex species is not expected to exhibit optical isomerism?

- (A) $[\text{Co}(\text{en})_2 \text{Cl}_2]^+$ (B) $[\text{Co}(\text{NH}_3)_3 \text{Cl}_3]$ (C) $[\text{Co}(\text{en})(\text{NH}_3)_2 \text{Cl}_2]^+$ (D) $[\text{Co}(\text{en})_3]^{3+}$

Solution

$[\text{Co}(\text{NH}_3)_3 \text{Cl}_3]$ exists in two forms (*facial* and *meridional*).



Both of these forms are achiral. Hence $[\text{Co}(\text{NH}_3)_3 \text{Cl}_3]$ does not show optical isomerism.

Hence, the correct option is (B).

Solution

We know that

$$C^* = \sqrt{\frac{2RT}{M}}, \bar{C} = \sqrt{\frac{8RT}{\pi M}}, C = \sqrt{\frac{3RT}{M}}$$

Thus, we have

$$C^* : \bar{C} : C = \sqrt{2} : \sqrt{\frac{8}{\pi}} : \sqrt{3}$$

Solving, we get $C^* : \bar{C} : C = 1.414 : 1.595 : 1.732 = 1 : 1.128 : 1.225$

Hence, the correct option is (B).

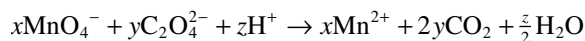
24. The gas leaked from a storage tank of the Union Carbide plant in Bhopal gas tragedy was
 (A) methylamine (B) ammonia (C) phosgene (D) methyl isocyanate

Solution

It was methyl isocyanate (C_2H_3NO).

Hence, the correct option is (D).

25. Consider the following reaction



The values of x , y and z in the reaction are, respectively

- (A) 2, 5 and 8 (B) 2, 5 and 16 (C) 5, 2 and 8 (D) 5, 2 and 16

Solution

The balanced equation is $2MnO_4^- + 5C_2O_4^{2-} + 16H^+ \rightarrow 2Mn^{2+} + 10CO_2 + 8H_2O$

Hence, $x = 2, y = 5, z = 16$

Hence, the correct option is (B).

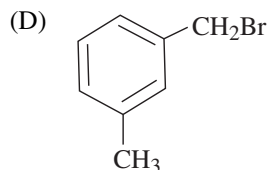
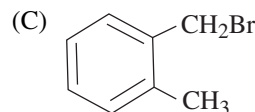
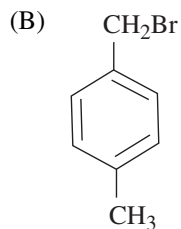
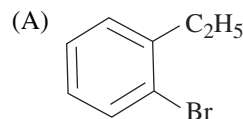
26. Which of the following exists as covalent crystals in the solid state?
 (A) Silicon (B) Sulphur (C) Phosphorus (D) Iodine

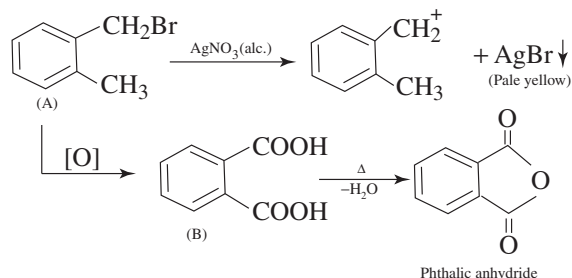
Solution

Silicon (Si) exists as covalent solid, sulphur (S_8) exists as molecular solid, phosphorous (P_4) exists as molecular solid and iodine (I_2) exists as molecular solid.

Hence, the correct option is (A).

27. Compound (A), C_8H_9Br , gives a white precipitate when warmed with alcoholic $AgNO_3$. Oxidation of (A) gives an acid (B), $C_8H_6O_4$. (B) easily forms anhydride on heating. Identify the compound (A).



Solution

Hence, the correct option is (C).

28. Energy of an electron is given by $E = -2.178 \times 10^{-18} \text{ J} \left(\frac{Z^2}{n^2} \right)$. Wavelength of light required to excite an electron in

an hydrogen atom from level $n = 1$ to $n = 2$ will be

($h = 6.62 \times 10^{-34} \text{ J s}$ and $c = 3.0 \times 10^8 \text{ m s}^{-1}$)

- (A) $2.816 \times 10^{-7} \text{ m}$ (B) $6.500 \times 10^{-7} \text{ m}$
 (C) $8.500 \times 10^{-7} \text{ m}$ (D) $1.214 \times 10^{-7} \text{ m}$

Solution

$$E = \frac{hc}{\lambda} = 2.178 \times 10^{-18} \times Z^2 \left[\frac{1}{1^2} - \frac{1}{2^2} \right] \Rightarrow \lambda = 1.214 \times 10^{-7} \text{ m}$$

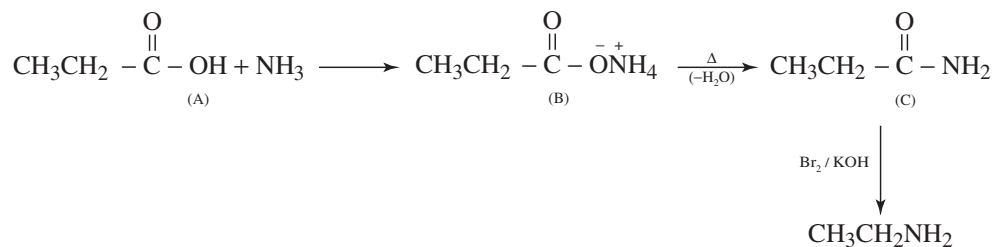
Hence, the correct option is (D).

29. An organic compound A upon reacting with NH_3 gives B. On heating B gives C. C in presence of KOH react with Br_2 to give $\text{CH}_3\text{CH}_2\text{NH}_2$. A is

- (A) $\text{CH}_3\text{CH}_2\text{CH}_2\text{COOH}$ (B) $\text{H}_3\text{C}-\underset{\text{CH}_3}{\text{CH}}-\text{COOH}$
 (C) $\text{CH}_3\text{CH}_2\text{COOH}$ (D) CH_3COOH

Solution

The reaction can be illustrated as



Hence, the correct option is (C).

30. In which of the following pairs of molecules/ions, both the species are not likely to exist?

- (A) $\text{H}_2^-, \text{He}_2^{2-}$ (B) $\text{H}_2^{2+}, \text{He}_2$ (C) $\text{H}_2^-, \text{He}_2^{2+}$ (D) $\text{H}_2^-, \text{He}_2^{2+}$

Solution

Bond order of H_2^{2+} and He_2 is zero, thus their existence is not possible.

Hence, the correct option is (B).

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