FINAL JEE–MAIN EXAMINATION – MARCH, 2021
Held On Tuesday 16th March, 2021
TIME: 9:00 AM to 12:00 NOON

SECTION-A

1. Given below are two statement : one is labelled as Assertion A and the other is labelled as Reason R :
Assertion A : Size of Bk^{3+} ion is less than Np^{3+} ion.
Reason R : The above is a consequence of the lanthanoid contraction.
In the light of the above statements, choose the correct answer from the options given below :
(1) A is false but R is true
(2) Both A and R are true but R is not the correct explanation of A
(3) Both A and R are true and R is the correct explanation of A
(4) A is true but R is false
Official Ans. by NTA (3)

Sol. Size of $_{97}Bk$ ion is less than that of $_{93}Np^{3+}$ due to actinoid contraction.
As we know that in a period from left to right ionic radius decreases and in actinide series it is due to actinoid contraction.

2. Which among the following pairs of Vitamins is stored in our body relatively for longer duration ?
(1) Thiamine and Vitamin A
(2) Vitamin A and Vitamin D
(3) Thiamine and Ascorbic acid
(4) Ascorbic acid and Vitamin D
Official Ans. by NTA (2)

Sol. Vitamin-A & Vitamin-D

3. Given below are two statements :
Statement I : Both $CaCl_2.6H_2O$ and $MgCl_2.8H_2O$ undergo dehydration on heating.
Statement II : BeO is amphoteric whereas the oxides of other elements in the same group are acidic.
In the light of the above statements, choose the correct answer from the options given below :
(1) Statement I is false but statement II is true
(2) Both statement I and statement II are false
(3) Both statement I and statement II are true
(4) Statement I is true but statement II is false
Official Ans. by NTA (2)

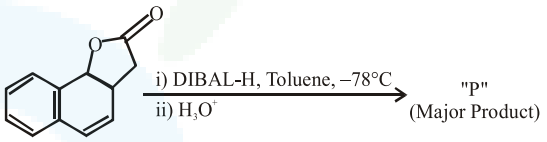
Sol. (a) $CaCl_2.6H_2O \xrightarrow{\Delta} \underset{\text{(Anhydrous)}}{CaCl_2} + 6H_2O$

(b) $MgCl_2.8H_2O \xrightarrow{\Delta} MgO + 2HCl + 6H_2O$

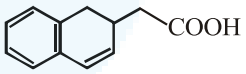
The dehydration of hydrated chloride of calcium can be achieved. The corresponding hydrated chloride of magnesium on heating suffer hydrolysis.

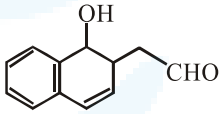
(c) BeO → Amphoteric

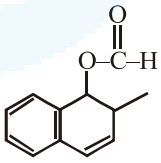
MgO
CaO
SrO
BaO
⇒ All are basic oxide

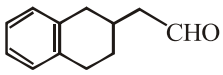
4. 

The product "P" in the above reaction is :

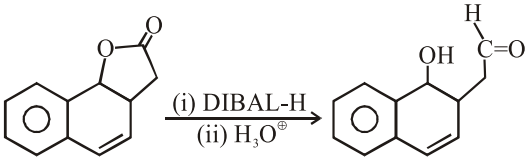
(1) 

(2) 

(3) 

(4) 

Official Ans. by NTA (2)

Sol. 

DIBAL can not reduce double bond
It can reduce cyclic ester.

5. Match List-I with List-II :

List-I Industrial process	List-II Application
(a) Haber's process	(i) HNO_3 synthesis
(b) Ostwald's process	(ii) Aluminium extraction
(c) Contact process	(iii) NH_3 synthesis
(d) Hall-Heroult process	(iv) H_2SO_4 synthesis

Choose the correct answer from the options given below :

(1) (a)-(ii), (b)-(iii), (c)-(iv), (d)-(i)

(2) (a)-(iii), (b)-(iv), (c)-(i), (d)-(ii)

(3) (a)-(iii), (b)-(i), (c)-(iv), (d)-(ii)

(4) (a)-(iv), (b)-(i), (c)-(ii), (d)-(iii)

Official Ans. by NTA (3)

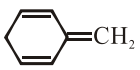
Sol. (a) Haber's process is used for NH_3 synthesis.

(b) Ostwald's process is used for HNO_3 synthesis.

(c) Contact process is used for H_2SO_4 synthesis.

(d) In Hall-Heroult process, electrolytic reduction of impure alumina can be done. (Aluminium extraction)

6. Among the following, the aromatic compounds are :

(A)  (B) 

(C)  (D) 

Choose the correct answer from the following options :

(1) (A) and (B) only

(2) (B) and (C) only

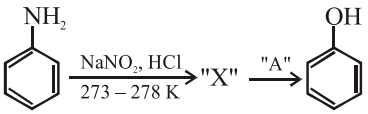
(3) (B), (C) and (D) only

(4) (A), (B) and (C) only

Official Ans. by NTA (2)

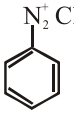
Sol. (A) Non-Aromatic (B) Aromatic

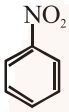
(C) Aromatic (D) Anti-Aromatic

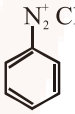
7. 

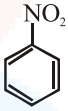
Major Product

In the above chemical reaction, intermediate "X" and reagent/condition "A" are :

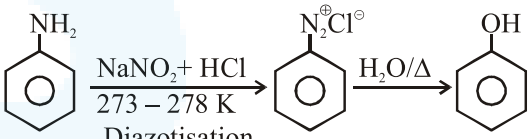
(1) X-  ; A- H_2O/NaOH

(2) X-  ; A- H_2O/Δ

(3) X-  ; A- H_2O/Δ

(4) X-  ; A- H_2O/NaOH

Official Ans. by NTA (3)

Sol. 

8. Given below are two statements :

Statement I : The E° value of Ce^{4+} / Ce^{3+} is + 1.74 V.

Statement II : Ce is more stable in Ce^{4+} state than Ce^{3+} state.

In the light of the above statements, choose the most appropriate answer from the options given below :

(1) Both statement I and statement II are correct

(2) Statement I is incorrect but statement II is correct

(3) Both statement I and statement II are incorrect

(4) Statement I is correct but statement II is incorrect

Official Ans. by NTA (4)

Sol. The E° value for Ce^{4+}/Ce^{3+} is +1.74 V because the most stable oxidation state of lanthanide series elements is +3.
It means Ce^{3+} is more stable than Ce^{4+}.

9. The functions of antihistamine are :

(1) Antiallergic and Analgesic

(2) Antacid and antiallergic

(3) Analgesic and antacid

(4) Antiallergic and antidepressant

Official Ans. by NTA (2)

10. Which of the following is Lindlar catalyst ?

(1) Zinc chloride and HCl

(2) Cold dilute solution of $KMnO_4$

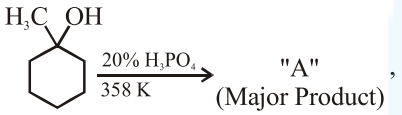
(3) Sodium and Liquid NH_3

(4) Partially deactivated palladised charcoal

Official Ans. by NTA (4)

Sol. Partially deactivated palladised charcoal (H_2/pd/$CaCO_3$) is lindlar catalyst.

11.



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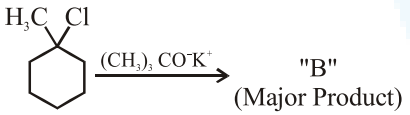

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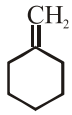
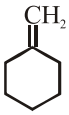
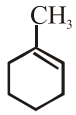
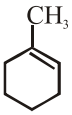
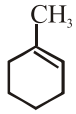
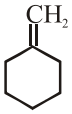
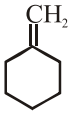
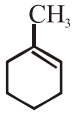
The product "A" and "B" formed in above reactions are :

(1) A-  B- 

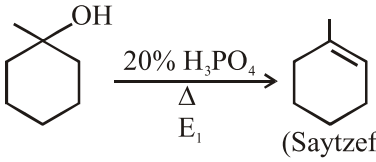
(2) A-  B- 

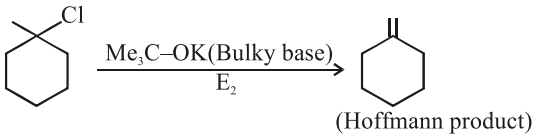
(3) A-  B- 

(4) A-  B- 

Official Ans. by NTA (3)

Sol.





12. Given below are two statements :
Statement I : H_2O_2 can act as both oxidising and reducing agent in basic medium.
Statement II : In the hydrogen economy, the energy is transmitted in the form of dihydrogen.
In the light of the above statements, choose the correct answer from the options given below :
(1) Both statement I and statement II are false
(2) Both statement I and statement II are true
(3) Statement I is true but statement II is false
(4) Statement I is false but statement II is true
Official Ans. by NTA (2)

Sol. (a) H_2O_2 can acts as both oxidising and reducing agent in basic medium.
(i) $2Fe^{2+} + H_2O_2 \rightarrow 2Fe^{3+} + 2OH^-$
In this reaction, H_2O_2 acts as oxiding agent.
(ii) $2\overset{+7}{M}nO_4^- + 3H_2O_2 \rightarrow 2\overset{+4}{M}nO_2 + 3O_2 + 2H_2O + 2OH^-$
In this reaction, H_2O_2 acts as reducing agent.
(b) The basic principle of hydrogen economy is the transportation and storage of energy in the form of liquids or gaseous dihydrogen.
Advantage of hydrogen economy is that energy is transmitted in the form of dihydrogen and not as electric power

13. The type of pollution that gets increased during the day time and in the presence of O_3 is :
(1) Reducing smog (2) Oxidising smog
(3) Global warming (4) Acid rain
Official Ans. by NTA (2)

Sol. In presence of ozone(O_3), oxidising smog gets increased during the day time because automobiles and factories produce main components of the photochemcial smog (oxidising smog) results from the action of sunlight on unsaturated hydrocarbon and nitrogen oxide.
Ozone is strong oxidising agent and can react with the unburnt hydrocarbons in the polluted air to produce chemicals.

14. Assertion A : Enol form of acetone [CH_3COCH_3] exists in < 0.1% quantity. However, the enol form of acetyl acetone [$CH_3COCH_2OCCH_3$] exists in approximately 15% quantity.

Reason R : enol form of acetyl acetone is stabilized by intramolecular hydrogen bonding, which is not possible in enol form of acetone.

Choose the correct statement :

(1) A is false but R is true

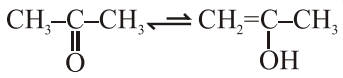
(2) Both A and R are true and R is the correct explanation of A

(3) Both A and R are true but R is not the correct explanation of A

(4) A is true but R is false

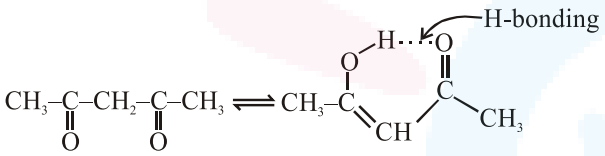
Official Ans. by NTA (2)

Sol.



(Keto form) (enol form)

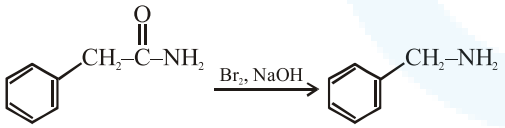
enol from of acetone is very less (< 0.1 %)



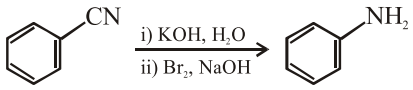
enol from (more than 50%)

15. Which of the following reaction DOES NOT involve Hoffmann Bromamide degradation ?

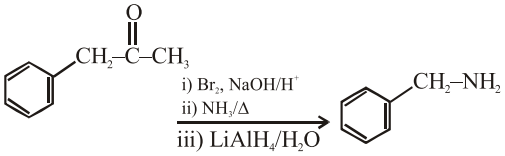
(1)



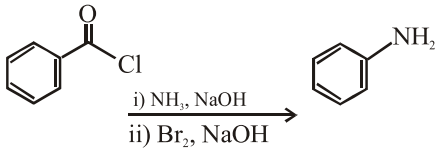
(2)



(3)

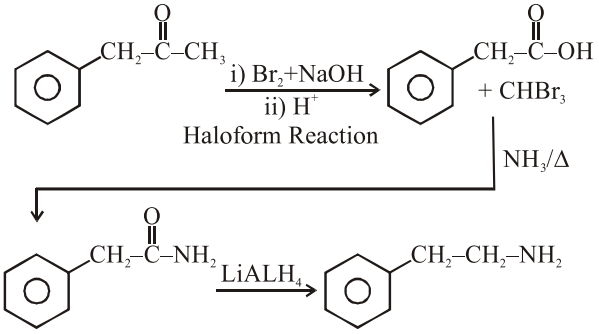


(4)



Official Ans. by NTA (3)

Sol.



⇒ This reaction does not involve haffmann bromanide degradation.

⇒ Rest all options involve haffmann bromamide degradation during the reaction of Br_2+NaOH with amide.

16. The process that involves the removal of sulphur from the ores is :

(1) Smelting

(2) Roasting

(3) Leaching

(4) Refining

Official Ans. by NTA (2)

Sol. In roasting process, metal sulphide (MS) ore are converted into metal oxide and sulphur is remove in the form of SO_2 gas.

$$2MS + 3O_2 \xrightarrow{\Delta} 2MO + 2SO_2\uparrow$$

17. Match List-I with List-II :

	List-I	**List-II**
	Name of oxo acid	Oxidation state of 'P'
(a)	Hypophosphorous acid	(i) +5
(b)	Orthophosphoric acid	(ii) +4
(c)	Hypophosphoric acid	(iii) +3
(d)	Orthophosphorous acid	(iv) +2
		(v) +1

Choose the correct answer from the options given below :

(1) (a)-(v), (b)-(i), (c)-(ii), (d)-(iii)

(2) (a)-(iv), (b)-(i), (c)-(ii), (d)-(iii)

(3) (a)-(iv), (b)-(v), (c)-(ii), (d)-(iii)

(4) (a)-(v), (b)-(iv), (c)-(ii), (d)-(iii)

Official Ans. by NTA (1)

Sol. (a) Hypophosphorus acid : H_3PO_2

$(+1)\ 3 + x + (-2)2 = 0$

$x = +1$

(b) Orthophosphoric acid : H_3PO_4

$(+1)\ 3 + x + (-2)4 = 0$

$x = +5$

(c) Hypophosphoric acid : $H_4P_2O_6$

$(+1)\ 4 + 2x + (-2)6 = 0$

$x = +4$

(d) Orthophosphorous acid : H_3PO_3

$(+1)3 + x + (-2)3 = 0$

$x = +3$

18. Given below are two statements : one is labelled as Assertion A and the other is labelled as Reason R :

Assertion A : The H–O–H bond angle in water molecule is 104.5°.

Reason R : The lone pair – lone pair repulsion of electrons is higher than the bond pair - bond pair repulsion.

(1) A is false but R is true

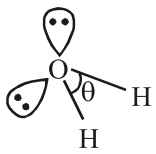
(2) Both A and R are true, but R is not the correct correct explanation of A

(3) A is true but R is false

(4) Both A and R are true, and R is the correct explanation of A

Official Ans. by NTA (4)

Sol. H_2O



$\theta = 104.5°$

the hybridisation of oxygen is water molecule is sp^3.

So electron geometry of water molecule is tetrahedral and the bond angle should be 109°28" but as we know that lone pair-lone pair repulsion of electrons is higher than the bond pair-bond pair repulsion because lone pair is occupied more space areound central atom than that of bond pair.

19. In chromotography technique, the purification of compound is independent of :

(1) Mobility or flow of solvent system

(2) Solubility of the compound

(3) Length of the column or TLC Plate

(4) Physical state of the pure compound

Official Ans. by NTA (4)

Sol. In chromotography technique, the purification of a compound is independent of the physical state of the pure compound.

20. A group 15 element, which is a metal and forms a hydride with strongest reducing power among group 15 hydrides. The element is :

(1) Sb (2) P (3) As (4) Bi

Official Ans. by NTA (4)

Sol. In group 15

N, P → Non metal

As, Sb → Metalloid

Bi → Metal

Hydrides of group 15 elements are

NH_3

PH_3

AsH_3

SbH_3

BiH_3

In NH_3, hydrogen atom gets partial positive charge due to less electronegativity.

But in BiH_3, hydrogen atom gets partial negative charge because hydrogen is more electronegative than bismuth.

i.e. BiH_3 is a strong reducing agent than others because we know that H^- is a strong reducing agent.

SECTION-B

1. For the reaction $A(g) \rightleftharpoons B(g)$ at 495 K, $\Delta_r G^o = -9.478$ kJ mol^{-1}.

If we start the reaction in a closed container at 495 K with 22 millimoles of A, the amount of B is the equilibrium mixture is _____ millimoles. (Round off to the Nearest Integer).

[R = 8.314 J mol^{-1} K^{-1}; $\ell n\ 10 = 2.303$]

Official Ans. by NTA (20)

Sol. $\Delta G^\circ = -RT\ \ell n\ K_{eq}$

Given $\Delta G^\circ = -9.478$ KJ/mole

$T = 495K \quad R = 8.314\ J\ mol^{-1}$

So $-9.478 \times 10^3 = -495 \times 8.314 \times \ell n\ K_{eq}$

$\ell n\ K_{eq} = 2.303$

$= \ell n\ 10$

So $K_{eq} = 10$

Now $A(g) \rightleftharpoons B(g)$

$t = 0 \quad 22 \quad 0$

$t = t \quad 22-x \quad x$

$$K_{eq} = \frac{[B]}{[C]} = \frac{x}{22-x} = 10$$

or $x = 20$

So millmoles of B = 20

2. Complete combustion of 750 g of an organic compound provides 420 g of CO_2 and 210 g of H_2O. The percentage composition of carbon and hydrogen in organic compound is 15.3 and _____ respectively. (Round off to the Nearest Integer)

Official Ans. by NTA (3)

Sol. 44 gm CO_2 have 12 gm carbon

So, 420 gm $CO_2 \Rightarrow \frac{12}{44} \times 420$

$\Rightarrow \frac{1260}{11}$ gm carbon

$\Rightarrow 114.545$ gram carbon

So, % of carbon $= \frac{114.545}{750} \times 100$

$\simeq 15.3\%$

18 gm $H_2O \Rightarrow 2$ gm H_2

210 gm $\Rightarrow \frac{2}{18} \times 210$

$= 23.33$ gm H_2

So, % $H_2 \Rightarrow \frac{23.33}{750} \times 100 = 3.11\%$

$\approx 3\%$

3. $2\ MnO_4^- + b\ C_2O_4^{2-} + c\ H^+ \rightarrow x\ Mn^{2+} + y\ CO_2 + z\ H_2O$

If the above equation is balanced with integer coefficients, the value of c is _____.
(Round off to the Nearest Integer).

Official Ans. by NTA (16)

Sol. Writting the half reaction

oxidation half reaction

$MnO_4^- \rightarrow Mn^{2+}$

balancing oxygen

$MnO_4^- \rightarrow Mn^{2+} + 4H_2O$

balancing Hydrogen

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

balancing charge

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

Reduction half

$C_2O_4^{2-} \rightarrow CO_2$

Balancing carbon

$C_2O_4^{2-} \rightarrow 2CO_2$

Balancing charge

$C_2O_4^{2-} \rightarrow 2CO_2 + 2e^-$

Net equation

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

So c = 16

4. AB_2 is 10% dissociated in water to A^{2+} and B^-. The boiling point of a 10.0 molal aqueous solution of AB_2 is _____°C. (Round off to the Nearest Integer).

[Given : Molal elevation constant of water $K_b = 0.5$ K kg mol^{-1} boiling point of pure water = 100°C]

Official Ans. by NTA (106)

Sol. $AB_2 \rightarrow A^{2+} + 2B^-$

$t = 0 \quad a \quad 0 \quad 0$

$t = t \quad a - a\alpha \quad a\alpha \quad 2a\alpha$

$n_T = a - a\alpha + a\alpha + 2a\alpha$

$= a\ (1 + 2\alpha)$

so $i = 1 + 2\alpha$

Now $\Delta T_b = i \times m \times K_b$

$\Delta T_b = (1 + 2\alpha) \times m \times K_b$

$\alpha = 0.1 \quad m = 10 \quad K_b = 0.5$

$\Delta T_b = 1.2 \times 10 \times 0.5$

$= 6$

So boiling point = 106

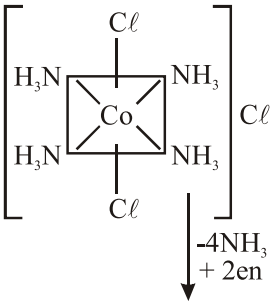
5. The equivalents of ethylene diamine required to replace the neutral ligands from the coordination sphere of the trans-complex of $CoCl_3.4NH_3$ is _____. (Round off to the Nearest Integer).

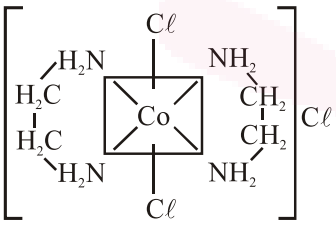
Official Ans. by NTA (2)

Sol. trans - $CoCl_3.4NH_3$

or

trans-$[Co(NH_3)_4Cl_2]C\ell$





As we know that ethylene diamine is a bidentate ligand and ammonia is a mono dentate ligand.

It means overall two ethylene diamine is required to replace the all neutral ligands (four ammonia) from the coordination sphere of this complex.

6. A 6.50 molal solution of KOH (aq.) has a density of 1.89 g cm^{-3}. The molarity of the solution is _____ mol dm^{-3}. (Round off to the Nearest Integer).

[Atomic masses: K :39.0 u; O :16.0 u; H :1.0 u]

Official Ans. by NTA (9)

Sol. 6.5 molal KOH = 1000gm solvent has 6.5 moles KOH

so wt of solute = 6.5 × 56

= 364 gm

wt of solution = 1000 + 364 = 1364

$$\text{Volume of solution} = \frac{1364}{1.89} m\ell$$

$$\text{Molarity} = \frac{\text{mole of solute}}{V_{solution} \text{ in Litre}}$$

$$= \frac{6.5 \times 1.89 \times 1000}{1364}$$

$$= 9.00$$

7. When light of wavelength 248 nm falls on a metal of threshold energy 3.0 eV, the de-Broglie wavelength of emitted electrons is _____ Å. (Round off to the Nearest Integer).

[Use : $\sqrt{3} = 1.73$, $h = 6.63 \times 10^{-34}$ Js

$m_e = 9.1 \times 10^{-31}$ kg ; $c = 3.0 \times 10^8$ ms^{-1} ; $1eV = 1.6 \times 10^{-19}J$]

Official Ans. by NTA (9)

Sol. Energy incident = $\frac{hc}{\lambda}$

$$= \frac{6.63 \times 10^{-34} \times 3.0 \times 10^8}{248 \times 10^{-9} \times 1.6 \times 10^{-19}} \text{ eV}$$

$$= \frac{6.63 \times 3 \times 100}{248 \times 1.6}$$

$= 0.05 \text{ eV} \times 100 = 5 \text{ eV}$

Now using

$E = \phi + K.E.$

$5 = 3 + K.E.$

$K.E. = 2eV = 3.2 \times 10^{-19}$ J

for debroglie wavelength $\lambda = \frac{h}{mv}$

$K.E = \frac{1}{2}mv^2$

so $v = \sqrt{\frac{2KE}{m}}$

hence $\lambda = \frac{h}{\sqrt{2KE \times m}}$

$$= \frac{6.63 \times 10^{-34}}{\sqrt{2 \times 3.2 \times 10^{-19} \times 9.1 \times 10^{-31}}}$$

$$= \frac{6.63}{7.6} \times \frac{10^{-34}}{10^{-25}} = \frac{66.3 \times 10^{-10} m}{7.6}$$

$= 8.72 \times 10^{-10}$ m

$\approx 9 \times 10^{-10} m$

$= 9Å$

8. Two salts A_2X and MX have the same value of solubility product of 4.0×10^{-12}. The ratio of their molar solubilities i.e. $\frac{S(A_2X)}{S(MX)} =$ _____.

(Round off to the Nearest Integer).

Official Ans. by NTA (50)

Sol. For A_2X

$A_2X \rightarrow 2A^+ + X^{2-}$

$2S_1 \quad S_1$

$K_{sp} = 4S_1^3 = 4 \times 10^{-12}$

$S_1 = 10^{-4}$

for MX

$MX \rightarrow M^+ + X^-$

$S_2 \quad S_2$

$K_{sp} = S_2^2 = 4 \times 10^{-12}$

$S_2 = 2 \times 10^{-6}$

so $\frac{S_{A_2X}}{S_{MX}} = \frac{10^{-4}}{2 \times 10^{-6}} = 50$

9. A certain element crystallises in a bcc lattice of unit cell edge length 27 Å. If the same element under the same conditions crystallises in the fcc lattice, the edge length of the unit cell in Å will be _____. (Round off to the Nearest Integer).

[Assume each lattice point has a single atom]

[Assume $\sqrt{3} = 1.73$, $\sqrt{2} = 1.41$]

Official Ans. by NTA (33)

Sol. For BCC $\sqrt{3}\, a = 4r$

so $r = \frac{\sqrt{3}}{4} \times 27$

for FCC $a = 2\sqrt{2}\, r$

$= 2 \times \sqrt{2} \times \frac{\sqrt{3}}{4} \times 27$

$= \frac{\sqrt{3}}{\sqrt{2}} \times 27$

$= 33$

10. The decomposition of formic acid on gold surface follows first order kinetics. If the rate constant at 300 K is 1.0×10^{-3} s^{-1} and the activation energy $E_a = 11.488$ kJ mol^{-1}, the rate constant at 200 K is _____ $\times 10^{-5}$ s^{-1}. (Round of to the Nearest Integer).

(Given : R = 8.314 J mol^{-1} K^{-1})

Official Ans. by NTA (10)

Sol. $K_{300} = 10^{-4}$ $\quad K_{200} = ?$

$E_a = 11.488$ KJ/mole $\quad R = 8.314$ J/mole-K

so $\ell n\left(\frac{K_{300}}{K_{200}}\right) = \frac{E_a}{R}\left(\frac{1}{200} - \frac{1}{300}\right)$

$\ell n\left(\frac{K_{300}}{K_{200}}\right) = \frac{11.488 \times 1000 \times 100}{8.314 \times 200 \times 300}$

$= 2.303$

$= \ell n 10$

so $\frac{K_{300}}{K_{200}} = 10$

$K_{200} = \frac{1}{10} \times K_{300} = 10^{-4}$

$= 10 \times 10^{-5}$ sec^{-1}