

JEE Main 2020 Paper



Date: 8th January 2020

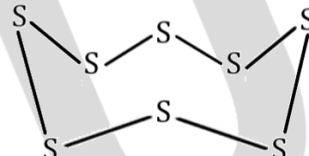
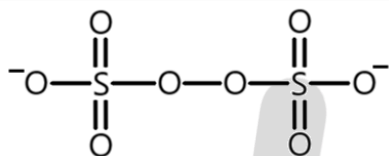
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Subject: Chemistry

1. The number of bonds between sulphur and oxygen atoms in $\text{S}_2\text{O}_8^{2-}$ and number of bonds between sulphur and sulphur atoms in rhombic sulphur, respectively, are:
- 8 and 6
 - 4 and 6
 - 8 and 8
 - 4 and 8

Answer: c

Solution: Here, we have to count S – O single bonds as well as S = O in $\text{S}_2\text{O}_8^{2-}$, as each double bond also has one sigma bond. The structure of $\text{S}_2\text{O}_8^{2-}$ and S_8 is shown below:



2. The predominant intermolecular forces present in ethyl acetate, a liquid, are:
- London dispersion, dipole-dipole and hydrogen bonding
 - hydrogen bonding and London dispersion
 - dipole-dipole and hydrogen bonding
 - London dispersion and dipole-dipole

Answer: d

Solution: London dispersion forces (also called as induced dipole - induced dipole interactions), exist because of the generation of temporary polarity due to collision of particles and for this very reason, they are present in all molecules and inert gases as well.

Because of the presence of a permanent dipole, there will be dipole-dipole interactions present here.

There is no H that is directly attached to an oxygen atom, so H-bonding cannot be present.



3. For the Balmer series in the spectrum of H-atom,

$$\bar{\nu} = R_H \left[\frac{1}{n_1^2} - \frac{1}{n_2^2} \right]$$

The correct statements among (A) to (D) are:

- A) The integer $n_1 = 2$.
 - B) The ionization energy of hydrogen can be calculated from the wave number of these lines.
 - C) The lines of longest wavelength corresponds to $n_2 = 3$.
 - D) As wavelength decreases, the lines of the series converge.
- a. B, C, D
 - b. A, B, D
 - c. A, C, D
 - d. A, B, C

Answer: c

Solution:

(A) is correct since the series studied in H-spectrum, including Balmer series, are de-excitation series or emission series. So, electrons get de-excited to $n = 2$ which means that $n_{\text{lower}} = 2$.

(B) It is possible to obtain I.E. from the formula above, but since the question has stated the formula for the Balmer series, n_{lower} has been fixed as 2. So, it is not possible to calculate I.E. from it. To calculate I.E., we'll have to put $n_{\text{lower}} = 1$, which isn't possible here.

(C) $\Delta E = hc/\lambda$

With n_{lower} fixed as 2, ΔE increases as n_{higher} is increased. So, the last line of the Balmer series, i.e. from infinity to $n = 2$, will have the maximum energy in the series and thus, the lowest wavelength. Similarly, the first line in the series, i.e. from $n = 3$ to $n = 2$ will have the lowest energy in the series and thus, the highest wavelength. Which makes this statement correct.

(D) As orbits with higher orbit number or those that are further away from the nucleus are considered, the energy gap in-between subsequent orbits decreases. Now, consider the following for example and with n_{lower} fixed as 2.

Energy of a photon released on transition from $n = 100$ to $n = 2$ will have similar energy to that of the photon that gets released on transition from $n = 101$ to $n = 2$, because energy of the 100th and the 101th orbit will be very close in value. That means they will also have very close values of wavelengths, which further implies that these two lines will be situated quite close to each other on the photographic plate.

In a similar fashion, we can see that as the n_{higher} increases, the lines start to converge together. And since, increasing the n_{higher} will indeed lead to an increase in the energy of the photon released, it will end up releasing photons of shorter wavelengths. Combining these two statements we can easily see that as the wavelength decreases, the spectral lines start to converge.



4. The first ionization energy (in kJ/mol) of Na, Mg, Al and Si, respectively, are:
- 496, 737, 577, 786
 - 496, 577, 737, 786
 - 496, 577, 786, 737
 - 786, 737, 577, 496

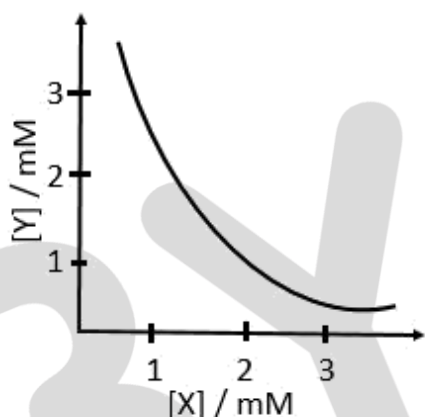
Answer: a

Solution:

The expected order is $\text{Na} < \text{Mg} < \text{Al} < \text{Si}$.

But the actual/experimental order turns out to be $\text{Na} < \text{Al} < \text{Mg} < \text{Si}$, because of the fully filled s-subshell of magnesium and the s^2p^1 configuration of Al which makes it relatively easy for Al to lose its outermost electron.

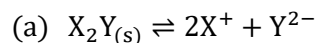
5. The stoichiometry and solubility product of a salt with the solubility curve given below is, respectively:



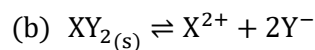
- X_2Y , $2 \times 10^{-9}\text{M}^3$
- XY_2 , $1 \times 10^{-9}\text{M}^3$
- XY_2 , $4 \times 10^{-9}\text{M}^3$
- XY , $2 \times 10^{-6}\text{M}^3$

Answer: c

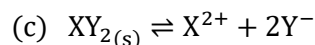
Solution:



$$K_{sp} = [\text{X}^+]^2[\text{Y}^{2-}] = 4 \times 10^{-6} \times 10^{-3} = 4 \times 10^{-9}$$

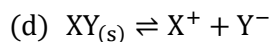


$$K_{sp} = [\text{X}^{2+}][\text{Y}^-]^2 = 10^{-3} \times 4 \times 10^{-6} = 4 \times 10^{-9}$$





$$K_{sp} = [X^{2+}][Y^{-}]^2 = 10^{-3} \times (2 \times 10^{-3})^2 = 4 \times 10^{-9}$$



$$K_{sp} = [X^{+}][Y^{-}] = 10^{-3} \times 10^{-3} = 10^{-6}$$

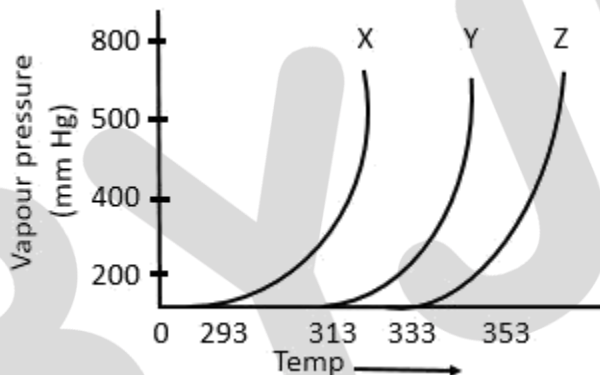
6. The complex that can show fac- and mer-isomers is:

- a. $[\text{Co}(\text{NO}_2)_3(\text{NH}_3)_3]$
- b. $[\text{PtCl}_2(\text{NH}_3)_2]$
- c. $[\text{Co}(\text{NH}_3)_4\text{Cl}_2]^{+}$
- d. $[\text{CoCl}_2(\text{en})_2]$

Answer: a

Solution: Facial and meridional geometrical isomerism is observed only in $[\text{MA}_3\text{B}_3]$ type complexes which is given in option a.

7. A graph of vapour pressure and temperature for three different liquids X, Y and Z is shown below:



The following inferences are made:

- A) X has higher intermolecular interactions compared to Y
- B) X has lower intermolecular interactions compared to Y
- C) Z has lower intermolecular interactions compared to Y

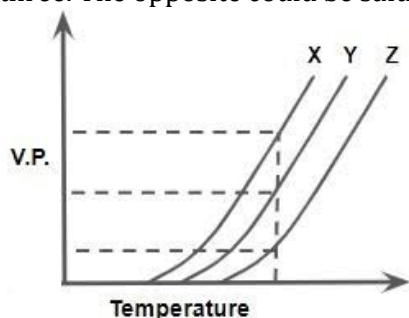
The correct inference(s) is/are:

- a. C
- b. A
- c. B
- d. A and C

Answer: c

Solution:

As shown in the plot below, for the same T, the vapour pressure of X is the highest and of Z is the lowest. Now, that means with the same average K.E. of X, Y and Z molecules, the X molecules are able to compensate their respective intermolecular forces better. So, X molecules have the highest vapour pressure. Which implies that the intermolecular forces in X are the weakest among the three. The opposite could be said for Z as well.



8. As per Hardy-Schulze formulation, the flocculation values of the following for ferric hydroxide sol are in the order:
- $\text{AlCl}_3 > \text{K}_3[\text{Fe}(\text{CN})_6] > \text{K}_2\text{CrO}_4 > \text{KBr} = \text{KNO}_3$
 - $\text{K}_3[\text{Fe}(\text{CN})_6] < \text{K}_2\text{CrO}_4 < \text{AlCl}_3 < \text{KBr} < \text{KNO}_3$
 - $\text{K}_3[\text{Fe}(\text{CN})_6] < \text{K}_2\text{CrO}_4 < \text{KBr} = \text{KNO}_3 = \text{AlCl}_3$
 - $\text{K}_3[\text{Fe}(\text{CN})_6] > \text{AlCl}_3 > \text{K}_2\text{CrO}_4 > \text{KBr} > \text{KNO}_3$

Answer: c

Solution:

The minimum concentration of an electrolyte which is required to cause the coagulation or flocculation of a sol is known as flocculation value.

Flocculation value is inversely proportional to coagulation power (coagulation power is directly proportional to the valency of the ions causing coagulation). $\text{Fe}(\text{OH})_3$ sol is a positive sol and thus we have to consider the valency of the anions in the given electrolytes.

9. The rate of a certain biochemical reaction at physiological temperature (T) occurs 10^6 times faster with enzyme than without. The change in activation energy upon adding enzyme is:
- $-6RT$
 - $-6 \times 2.303 RT$
 - $+6RT$
 - $+6 \times 2.303 RT$

Answer: b



Solution:

$$K_1 = Ae^{-E_{a1}/RT} \text{----(1)}$$

$$K_2 = Ae^{-E_{a2}/RT} \text{----(2)}$$

Dividing equation 1 with equation 2, we get

$$\frac{K_1}{K_2} = e^{(E_{a2}-E_{a1})/RT}$$

$$10^{-6} = e^{(E_{a2}-E_{a1})/RT}$$

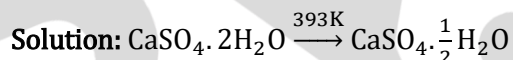
Taking \log_e on both sides, we get

$$\Delta E = E_{a2} - E_{a1} = -6 \times 2.303 RT$$

10. When gypsum is heated to 393K, it forms:

- a. $\text{CaSO}_4 \cdot \frac{1}{2} \text{H}_2\text{O}$
- b. Dead burnt plaster
- c. $\text{CaSO}_4 \cdot 5\text{H}_2\text{O}$
- d. Anhydrous CaSO_4

Answer: a



11. The third ionization enthalpy is minimum for:

- a. Mn
- b. Co
- c. Ni
- d. Fe

Answer: d

Solution:

Consider an element E

$E^{2+} \rightarrow E^{3+}$ would be the 3rd I.E. of the element E.

Electronic configuration of Mn is $[\text{Ar}]4s^23d^5$, Co is $[\text{Ar}]4s^23d^7$, Fe is $[\text{Ar}]4s^23d^6$, Ni is $[\text{Ar}]4s^23d^8$

Electronic configuration of Mn^{2+} is $[\text{Ar}]3d^5$, Co^{2+} is $[\text{Ar}]3d^7$, Fe^{2+} is $[\text{Ar}]3d^6$, Ni^{2+} is $[\text{Ar}]3d^8$

As it is evident from the above configurations of the E^{2+} for the given elements, Fe^{2+} would require the least amount of energy for removal of electron as it has the configuration $3d^6 4s^0$. That means that its E^{3+} form is the most stable among the four elements provided in their respective E^{3+} states, i.e., when compared, the next electron removal will require least amount of energy.

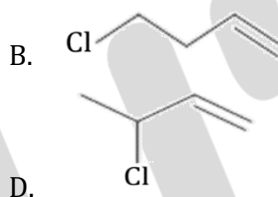
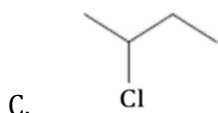
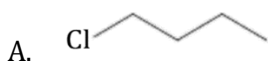


12. The strength of an aqueous NaOH solution is most accurately determined by titrating:
(Note: consider that an appropriate indicator is used)
- Aq. NaOH in a pipette and aqueous oxalic acid in a burette
 - Aq. NaOH in a volumetric flask and concentrated H_2SO_4 in a conical flask
 - Aq. NaOH in a burette and concentrated H_2SO_4 in a conical flask
 - Aq. NaOH in a burette and aqueous oxalic acid in a conical flask

Answer: d

Solution: The standard solution is usually kept in burette. The oxalic acid is a primary standard solution while H_2SO_4 is a secondary standard solution.

13. The decreasing order of reactivity towards dehydrohalogenation (E_1) reaction of the following compounds is:



D.

- $\text{B} > \text{A} > \text{D} > \text{C}$
- $\text{B} > \text{D} > \text{C} > \text{A}$
- $\text{B} > \text{D} > \text{A} > \text{C}$
- $\text{D} > \text{B} > \text{C} > \text{A}$

Answer: d

Solution: In E_1 mechanism, the rate determining step is formation of carbocation. So, stability of carbocation formed decides the rate.

In option D, the cation formed is resonance stabilised.

In option C, the cation formed is a 2° carbocation.

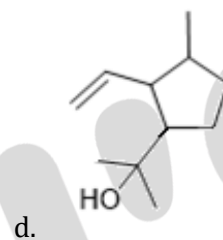
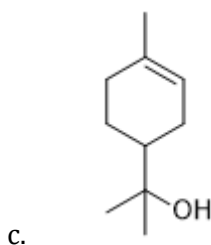
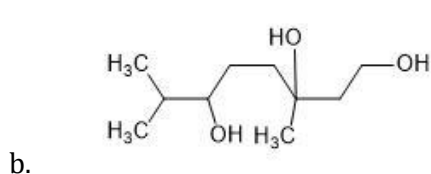
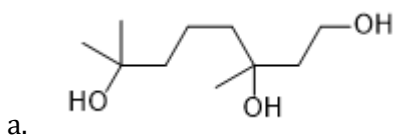
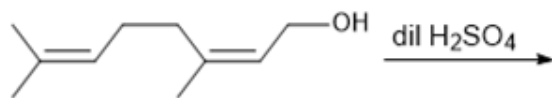
In option A and B, the carbocations formed are 1° but there is a chance of rearrangement in option b and after the rearrangement, the carbocation formed in option b will be allylic. So, the order of reaction is as follows:

$\text{D} > \text{B} > \text{C} > \text{A}$.

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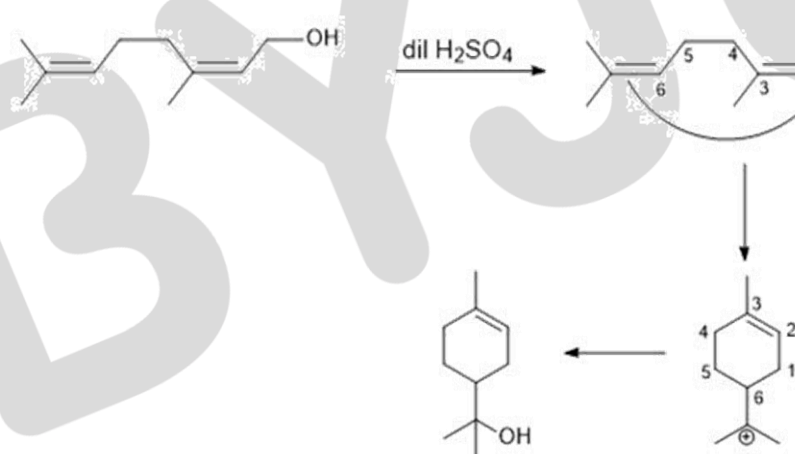


14. Major product in the following reaction is:



Answer: c

Solution:



15. Arrange the following compounds in increasing order of C—OH bond length: methanol, phenol, p-ethoxyphenol

- Phenol < methanol < p-ethoxyphenol
- methanol < p-ethoxyphenol < phenol
- Phenol < p-ethoxyphenol < methanol
- methanol < phenol < p-ethoxyphenol

Answer: c



Solution: In methanol, there is no resonance. In phenol, there is resonance. In p-Ethoxyphenol, there is resonance involved but the involvement of lone pair of oxygen in OH group is poor as compared with phenol due to the presence of lone pair oxygen in OCH_3 group which are also involved in resonance.

So, partial double bond character develops in C—OH bond of phenol and p-ethoxyphenol but in case of p-ethoxyphenol, resonance is poor as compared to phenol. So, bond length follows the order: methanol > p-ethoxyphenol > phenol

16. Among the gases (i) – (v), the gases that cause greenhouse effect are:

- i. CO_2
- ii. H_2O
- iii. CFC
- iv. O_2
- v. O_3
- a. i, ii iii and iv
- b. i, iii, iv and v
- c. i and iv
- d. i, ii, iii and v

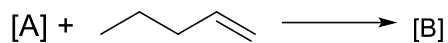
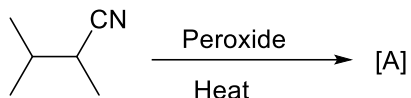
Answer: d

Solution: CO_2 , O_3 , H_2O vapours and CFC 's are green house gases.

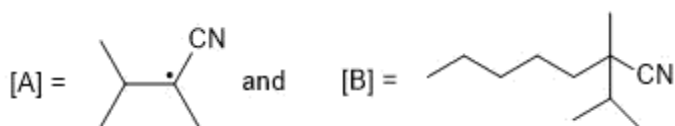
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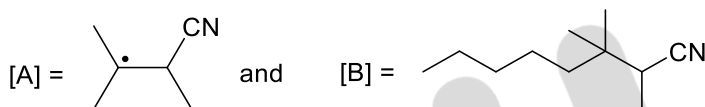
17. The major products A and B in the following reactions are:



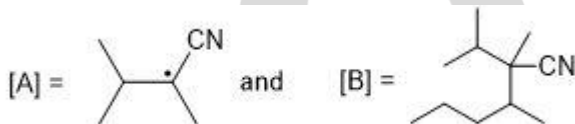
a.



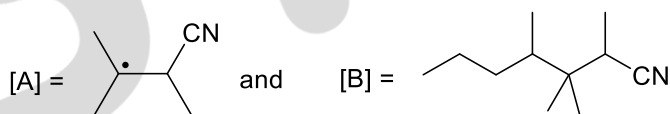
b.



c.



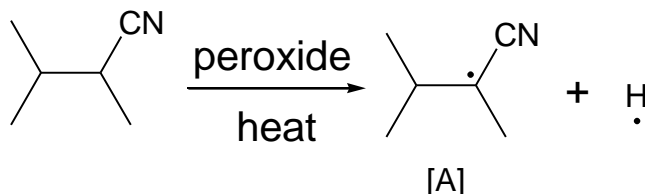
d.



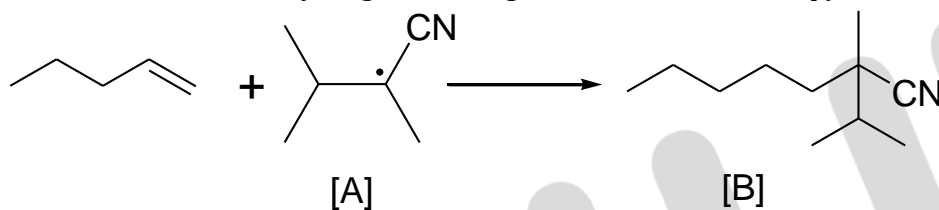
Answer: a

Solution:

First reaction will generate a free radical which is stabilized by cyanide group.



The alkene undergo homolytic cleavage at the double bond and the terminal radical couple with [A] (secondary radical being more stable will not couple with [A]) forming product B (the secondary radical combines with hydrogen radical generated in the first step).



18. A flask contains a mixture of isohexane and 3-methylpentane. One of the liquids boils at 63 °C while the other boils at 60 °C. What is the best way to separate the two liquids and which one will be distilled out first?
- Fractional distillation, isohexane
 - Simple distillation, 3-methylpentane
 - Fractional distillation, 3-methylpentane
 - Simple distillation, isohexane

Answer: a

Solution: When the difference between the B.P. of the two liquids is less than around 40 °C, fractional distillation is more efficient. The difference between the boiling points of isohexane and 3-methylpentane is only 3 degrees. So, fractional distillation is the best suitable method. Since, isohexane has a lower boiling point, it comes out first.

19. Which of the given statement is not true for glucose?
- The pentacetate glucose does not react with hydroxylamine to give oxime.
 - Glucose reacts with hydroxylamine to form oxime.
 - Glucose gives Schiff's test for aldehyde.
 - Glucose exists in two crystalline forms α and β .

Answer: c

Solution: Glucose exists in two crystalline forms α and β which are anomers of each other.

Glucose does not react with Schiff's reagent because after the internal cyclisation, it forms either α -anomer or β -anomer. In these forms, free aldehydic group is not present.

Glucose forms open chain structure in aqueous solution which contains aldehyde at chain end. This aldehydic group reacts with NH_4OH to form oxime. On the other hand, glucose penta acetate being a cyclic structure even in aqueous form does not have terminal carbonyl group. Therefore it will not react with NH_4OH .

20. The reagent used for the given conversion is:



- a. B_2H_6
- b. LiAlH_4
- c. NaBH_4
- d. H_2, Pd

Answer: a

Solution: B_2H_6 does not reduce amide, carbonyl group and cyanide. It selectively reduces carboxylic acid to alcohol. So, for this conversion, it is the best suitable reagent.

21. The volume (in mL) of 0.125 M AgNO_3 required to quantitatively precipitate chloride ions in 0.3 g of $[\text{Co}(\text{NH}_3)_6]\text{Cl}_3$ is ____.

$$M_{[\text{Co}(\text{NH}_3)_6]\text{Cl}_3} = 267.46 \text{ g/mol}$$

$$M_{\text{AgNO}_3} = 169.87 \text{ g/mol}$$

Answer: 26.92

Solution: To react completely with one mole of $[\text{ML}_6]\text{Cl}_3$, 3 moles of AgNO_3 is required.

0.3 g $[\text{ML}_6]\text{Cl}_3$ means $\frac{0.3}{267.46}$ moles of $[\text{ML}_6]\text{Cl}_3$.

So, moles of AgNO_3 required will be $\frac{0.3 \times 3}{267.46}$ moles

To find the volume,

$$\frac{0.3 \times 3}{267.46} = 0.125 \times V(L)$$

$$V(L) = 0.02692$$

$$V(\text{mL}) = 26.92$$

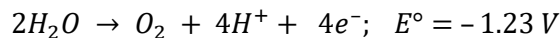


22. What will be the electrode potential for the given half cell reaction at pH= 5?
 $2H_2O \rightarrow O_2 + 4H^+ + 4e^-$; $E^\circ = -1.23 V$

($R=8.314 \text{ J mol}^{-1} \text{ K}^{-1}$; temp.=298 K; oxygen under std. atm. Pressure of 1bar.)

Answer: 1.52

Solution:



$$E = +1.23 - \frac{0.0591}{4} \log [H^+]^4$$

$$= +1.23 + (0.0591 \times \text{pH}) = +1.23 + 0.0591 \times 5$$

$$= +1.23 + 0.2955 = +1.5255 V$$

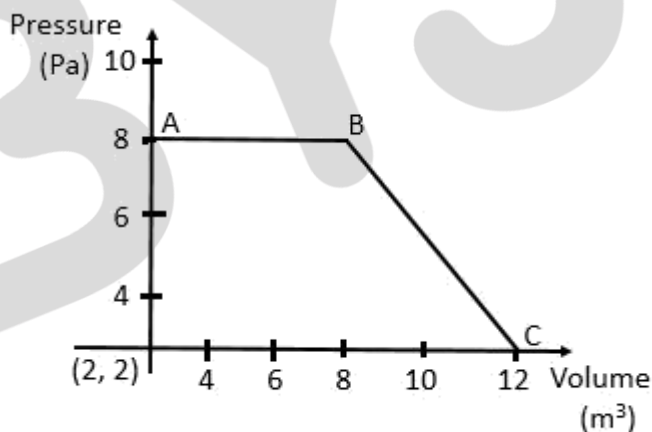
23. Ferrous sulphate heptahydrate is used to fortify foods with iron. The amount (in grams) of the salt required to achieve 10 ppm of iron in 100 kg of wheat is _____.
 Atomic weight: Fe=55.85; S=32.00; O=16.00)

Answer: 4.96

Solution: 10 ppm of Fe means 10 g of Fe in 10^6 g of wheat. So, for 100 kg i.e., 10^5 g

of wheat. Fe needed is 1 g. So, for 1 g of Fe, the mass of $FeSO_4 \cdot 7H_2O$ required is $\frac{278}{56} = 4.96$ g.

24. The magnitude of work done by gas that undergoes a reversible expansion along the path ABC shown in figure is _____.



Answer: 48

Solution:

Work done by the gas

= The area under the curve

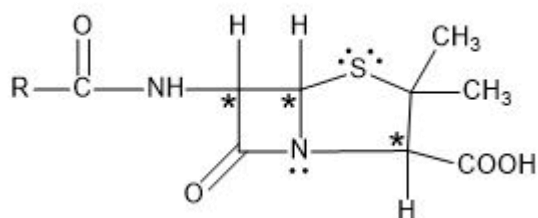
= (Area of the square) + (Area of the triangle)

= 48 J

25. The number of chiral centres in Penicillin is ____.

Answer: 3

Solution: The structure of penicillin is shown below:



So, the number of chiral centers = 3