Full Syllabus Test 2

Subject: Chemistry

1. For a d-electron, the orbital angular momentum is:

- ✔ **A.** $\sqrt{6}\frac{h}{2\pi}$
- ✘ **B.** $\sqrt{2}\frac{h}{2\pi}$
- ✘ **C.** $\frac{h}{2\pi}$
- ✘ **D.** $2\left(\frac{h}{2\pi}\right)$

The orbital angular momentum (L) $= \sqrt{l(l+1)}.\frac{h}{2\pi}$

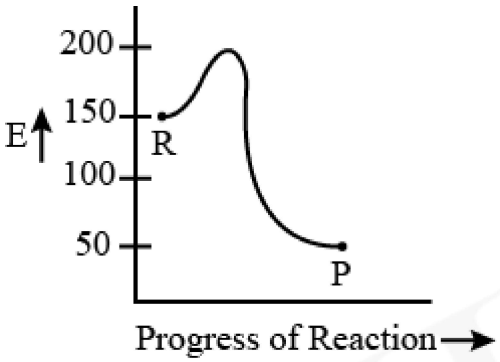
$= \sqrt{6}\frac{h}{2\pi}(\because\ l = 2$ for 'd' orbital)

2. An exothermic chemical reaction proceeds by two stages:

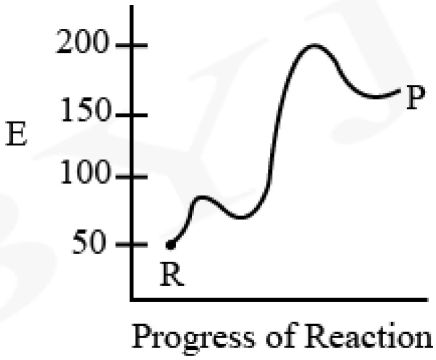
$$\text{Reactants} \overset{\text{stage 1}}{\rightarrow} \text{Intermediate} \overset{\text{stage 2}}{\rightarrow} \text{Products}$$

The activation energy of stage 1 is $50\ \text{kJ/mol}$. The overall enthalpy change of the reaction is $-100\ \text{kJ/mol}$. Which diagram could represent the energy level diagram for the other reaction.

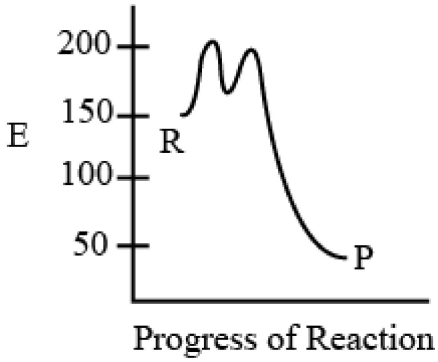
✗ **A.**



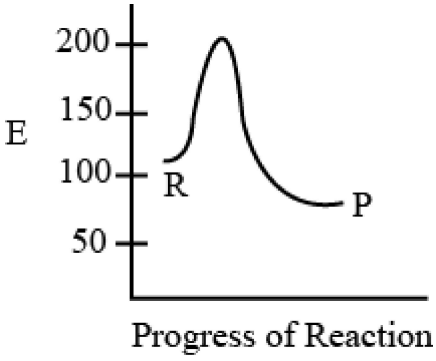
✗ **B.**



✓ **C.**



✗ **D.**



Since this is a multistep reaction, there would be two activated complexes formed. Also, since the total enthalpy change is negative, the products would be at a lower energy than the reactants. Keeping these ideas in mind, option c fits the description of the process.

3. The species present in solution when CO_2 is dissolved in water are:

- ✔ **A.** $CO_2,\ H_2CO_3,\ HCO_3^-,\ CO_3^{2-}$
- ✘ **B.** $H_2CO_3,\ CO_3^{2-}$
- ✘ **C.** $HCO_3^-,\ CO_3^{2-}$
- ✘ **D.** $CO_2,\ H_2CO_3$

When CO_2 is dissolved in water, the following equilibria are established:
$H_2O + CO_2 \rightleftharpoons H_2CO_3$
$H_2CO_3 \rightleftharpoons H^+ + HCO_3^-$
$HCO_3^- \rightleftharpoons H^+ + CO_3^{2-}$
Therefore, in solution, all of the above mentioned species exist.

4. How many coulombs of electricity are required for the oxidation of 1 mole of H_2O to O_2?

- ✘ **A.** $9.65 \times 10^4\ C$
- ✘ **B.** $4.825 \times 10^4\ C$
- ✔ **C.** $1.93 \times 10^5\ C$
- ✘ **D.** $3.86 \times 10^5\ C$

Oxidation of H_2O to O_2 is:
$2H_2O \rightarrow 4H^+ + O_2 + 4e^-$
Oxidation of 2 moles of water requires $96500 \times 4\ C$
$\therefore$ oxidation of 1 mole of water requires $= \dfrac{96500 \times 4}{2} = 1.93 \times 10^5\ C$

5. The circulation of blood in the human body supplies O_2 and releases CO_2. The concentration of O_2 and CO_2 is variable but on an average, 100 ml blood contains 0.02 g of O_2 and 0.08 g of CO_2. The volume of O_2 and CO_2 at 1 atm and at body temperature 37° C, assuming 10 l blood in the human body is:

- ✗ **A.** $2\text{ l},\ 4\text{ l}$
- ✗ **B.** $1.5\text{ l},\ 4.5\text{ l}$
- ✓ **C.** $1.59\text{ l},\ 4.62\text{ l}$
- ✗ **D.** $3.82\text{ l},\ 4.62\text{ l}$

$\because$ 100 ml blood has 0.02 g O_2 and $0.08\ g\ CO_2$
$\because$ 10,000 ml blood has 2 g O_2 and $8\ g\ CO_2$
Using $PV = nRT$,
For O_2,
$1 \times V_{O_2} = \frac{2}{32} \times 0.0821 \times 310$
$\Rightarrow V_{O_2} = 1.59$ litre
For CO_2, $1 \times V_{CO_2} = \frac{8}{44} \times 0.0821 \times 310 \Rightarrow V_{CO_2} = 4.62$ litre

6. The nodal plane in the π-bond of ethene is located in:

- ✓ **A.** The molecular plane
- ✗ **B.** A plane parallel to the molecular plane
- ✗ **C.** A plane perpendicular to the molecular plane which bisects the $(C-C)$ σ-bond at a right angle
- ✗ **D.** A plane perpendicular to the molecular plane which contains the $(C-C)$ σ-bond

The nodal plane in the π-bond of ethene is located in the molecular plane. Both the C atoms are sp^2 hybridized which results in a trigonal planar geometry. Thus, the $2C$ atoms and $4H$ atoms are present in one plane.

7. The strength of the bonds formed by overlapping of atomic orbitals is in the order:

A. $s-s>s-p>p-p$

B. $s-s>p-p>s-p$

C. $s-p>s-s>p-p$

D. $p-p>s-s>s-p$

The effective overlapping of orbitals decreases in the order:
$s-p>s-s>p-p$
The extent of overlap is higher for a hybrid orbital than their parent orbital and also s orbital than for a p orbital. Higher the extent of overlap, stronger is the bond formed.

8. Which among the following metals requires radiation of the shortest wavelength to cause emission of electrons?

A. Na

B. K

C. Mg

D. Ca

Ionisation energies of IIA group elements are greater than IA group
$(Mg, Ca)>(Na, K)$
Also,among IIA group elements first ionisation energy gradually decreases as we descend the group.
$Mg>Ca>Na>K$
Since energy is inversely proportional to wavelength, a radiation of the shortest wavelength means that energy should be high. The one with the highest ionisation energy among the given elements is Mg.

9. The reaction that takes place when Cl_2 gas is passed through conc. $NaOH$ solution is:

- ✗ **A.** Oxidation
- ✗ **B.** Reduction
- ✗ **C.** Displacement
- ✓ **D.** Disproportionation

$6NaOH + 3Cl_2 \rightarrow 5NaCl + NaClO_3 + 3H_2O$

Disproportionation as the oxidation state of chlorine goes from 0 to -1 in $NaCl$ and to $+5$ in $NaClO_3$.

10. When MnO_2 is fused with KOH, a coloured compound is formed. The compound and its colour are:

- ✓ **A.** K_2MnO_4, purple green
- ✗ **B.** $KMnO_4$, purple
- ✗ **C.** Mn_2O_3, brown
- ✗ **D.** Mn_3O_4, black

$2MnO_2 + 4KOH + O_2 \rightarrow \underset{\text{(purple green)}}{2K_2MnO_4} + 2H_2O$

11. The EAN of Fe in $[Fe(C_2O_4)_3]^{3-}$ is:

- A. 27
- B. 24
- C. 35 ✓
- D. 29

EAN = Atomic number - (Oxidation state of the metal) + 2 $\times$ Coordination number
$= 26 - 3 + (2 \times 6) = 35$

12. The atomic number of V, Cr, Mn and Fe are $23, 24, 25$ and 26 respectively. Which one of these may be expected to have the highest second ionisation enthalpy?

- A. V
- B. Cr ✓
- C. Mn
- D. Fe

The electronic configuration of the uni positive ions are given below:
$V^+ = 3d^3 4s^1$
$Cr^+ = 3d^5$
$Mn^+ = 3d^5 4s^1$
$Fe^+ = 3d^6 4s^1$

The IE_2 of Cr will be the highest as Cr^+ has a half-filled d-subshell.

13. Sulphur reacts with chlorine in $1:2$ ratio and forms (X). (X) on hydrolysis gives a sulphur compound (Y). What is the hybridisation of the central atom in the anion of (Y)?

A. sp

B. sp^3

C. sp^2

D. sp^3d

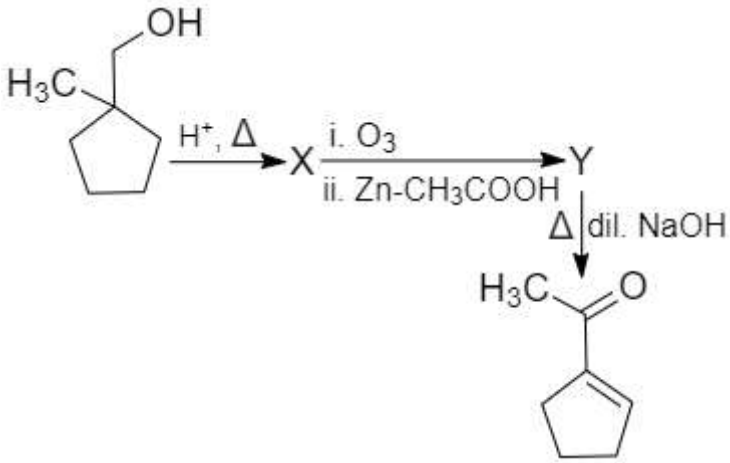
$$S + 2Cl_2 \rightarrow \underset{(X)}{SCl_4}$$

$$SCl_4 \xrightarrow{4H_2O} \underset{\text{(unstable)}}{S(OH)_4} + 4HCl$$

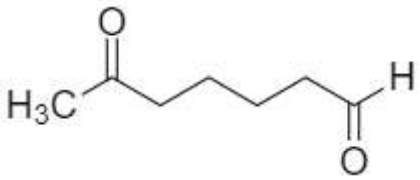
$$\underset{\text{(unstable)}}{S(OH)_4} \rightarrow \underset{(Y)}{H_2SO_3} + H_2O$$

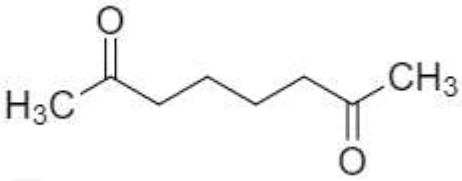
Hybridisation of S atom in SO_3^{2-} is sp^3

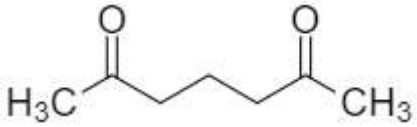
14.

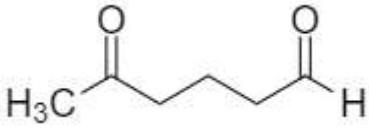


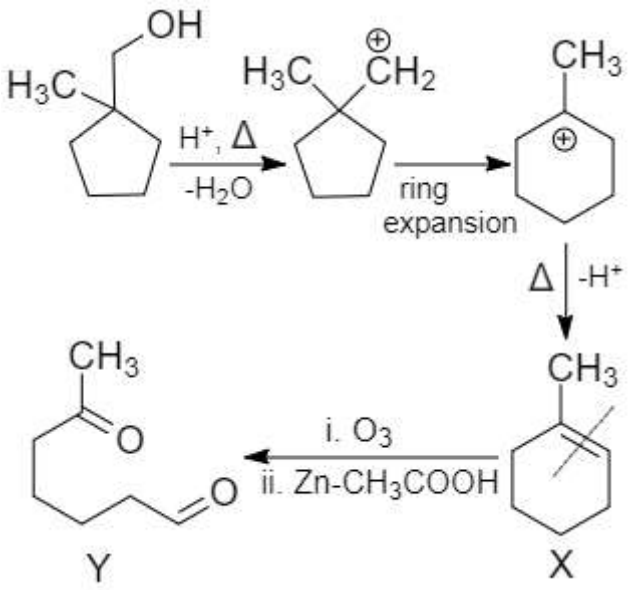
Identify Y.

A. 

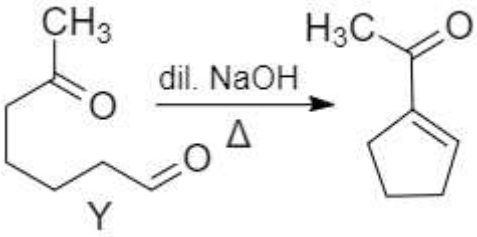
B. 

C. 

D. 



Y undergoes intramolecular aldol condensation to give one of the products given.



15. The effectiveness of an enzyme is least affected by:

- ✗ **A.** Temperature
- ✗ **B.** Concentraction of the substrate
- ✓ **C.** Original activation energy of the system
- ✗ **D.** Concentration of the enzyme

Enzyme activity is dependent on temperature, concentration of the enzyme, concentration of the substrate, and pH. However, the effectiveness of an enzyme is least affected by the original activation energy of the system. In other words, enzymes cannot alter the feasibility of a reaction but can alter the rate of a reaction.

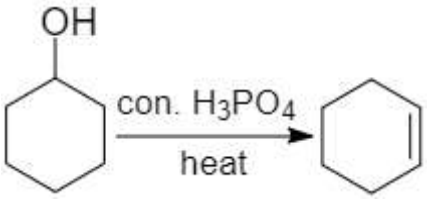
16. The best method to prepare cyclohexene from cyclohexanol is by using:

A. Conc. $HCl + ZnCl_2$

B. Conc. H_3PO_4/Δ

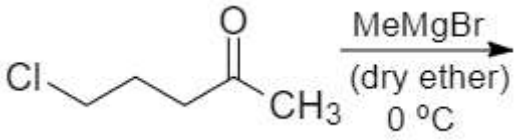
C. HBr

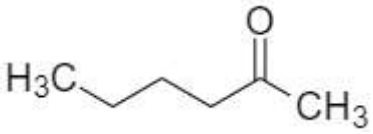
D. Conc. HCl

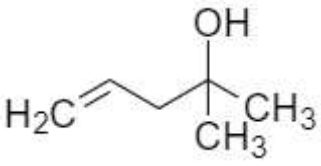


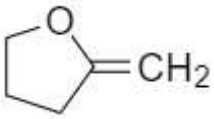
Conc. H_3PO_4 solution does not involve any substitution product.

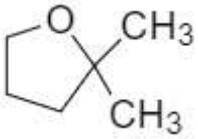
17. The major product in the following reaction is:

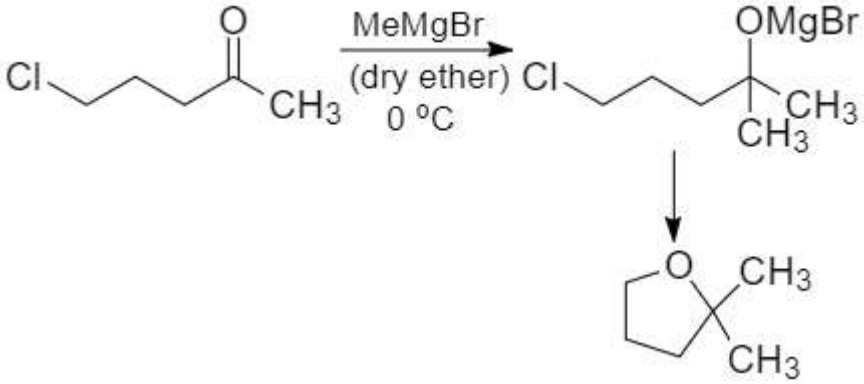


A. 

B. 

C. 

D. 



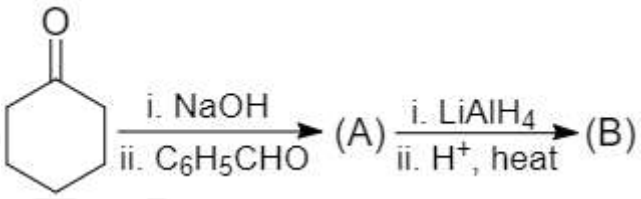
The first step is the nucleophilic addition of grignard reagent at the carbonyl carbon. Next step is an intramolecular substitution reaction.

18. $PhOH \xrightarrow[NaOH]{Me_2SO_4} P$

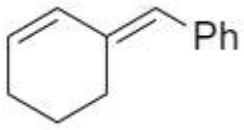
'P' is:

- ✗ **A.** $Ph - O - SO_2OMe$
- ✓ **B.** $PhOMe$
- ✗ **C.** $PhOSO_2OPh$
- ✗ **D.** $PhMe$

Me_2SO_4 i.e., Dimethyl sulphate is a methylating agent. When it is added to an alcohol in the presence of a base, the $O - H$ bond is broken and H is replaced by a methyl group.

19. 

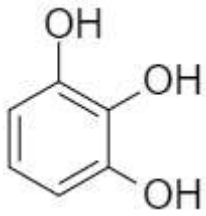
For the above reaction, addition of $LiAlH_4$ in dry ether takes place at low temperature $(-10\,^oC)$. What would be the product (B)?

- ✗ **A.**
- ✗ **B.**
- ✓ **C.** 

- ✗ **D.**

Low temperature favours the reduction of carbonyl group only into alcohol by $LiAlH_4/\text{dry ether}$. The alkene will remain unaffected.

20. What is the product formed when Gallic acid is heated?

A. 

B.

C.

D.

21. $(\Delta H - \Delta U)$ in J/mol for the formation of carbon monoxide (CO) from its elements at $300\ \mathrm{K}$ is:$R = \frac{25}{3}\mathrm{J/Kmol}$

Accepted Answers

12501250.01250.00

Solution:

$C(s) + \frac{1}{2}O_2(g) \rightarrow CO(g)$

$\Delta H = \Delta U + \Delta n_g RT$

$\Delta n_g = 1 - \frac{1}{2} = \frac{1}{2}$

$(\Delta H - \Delta U) = \frac{1}{2} \times \frac{25}{3} \times 300 = 1250\ \mathrm{J/mol}$

22. An ionic compound AB has a ZnS type of structure, if the radius A^+ is 22.5 pm, then the ideal radius of B^- so as not to cause any distortion is (in pm):

Accepted Answers

100 100.0 100.00

Solution:

Since, the ionic compound AB has a ZnS type of structure, therefore it has tetrahedral holes, for which

$$\frac{\text{Radius of Cation}}{\text{Radius of Anion}} = 0.225$$

$$\frac{r^+}{r^-} = 0.225$$

$$\frac{22.5}{r^-} = 0.225$$

$\therefore r^-$ = 100 pm

23. What volume of hydrogen gas (in litres) at 273 K and 1 atm pressure will be consumed to obtain 21.6 g of elemental boron (atomic mass = 10.8) from the reduction of boron trichloride by hydrogen?

Accepted Answers

67.20 67.2

Solution:

The underlying reaction is:

$2BCl_3 + 3H_2 \longrightarrow 2B + 6HCl$

Mass of boron formed = 21.6 g,

Moles of boron: $\frac{\text{mass}}{\text{molar mass}} = \frac{21.6\ \text{g}}{10.8\ \text{g/mol}} = 2\ \text{mol}$

Two moles of boron are formed, which means that 3 mol of hydrogen gas is consumed from the stoichiometry above.

Since, 1 mol of gas at STP occupies 22.4 L, 3 moles would occupy:

$3 \times 22.4 = 67.2\ \text{L}$

24. If the number of possible isomers for the compound $C_2FClBrI$ is x, then $x \times 2$ is:

Accepted Answers

12 12.0 12.00

Solution:

There are six isomers possible for the given formula, represented as follow:

25. How many moles of H_3PO_4 are obtained by hydrolysing two moles of P_4O_8?

Accepted Answers

4 4.0 4.00

Solution:

$P_4O_8 + 4H_2O \rightarrow 2H_2PO_3 + 2H_3PO_4$

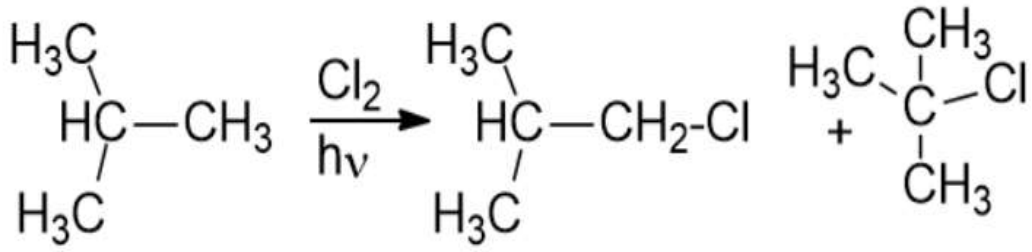
One mole of P_4O_8 gives two moles of H_3PO_4, so 2 moles would give four moles.

26. The number of types of monochloroalkanes formed by chlorination of isobutane is:

Accepted Answers

2 2.0 2.00

Solution:



27. Number of triclinic crystal system among the following

Graphite, ZnO, CdS, $(PbCO_3)$, HgS (cinnabar), $K_2Cr_2O_7$, $CuSO_4.5H_2O$, H_3BO_3

Accepted Answers

3 3.0 3.00

Solution:

In case of triclinic system, the axial distances are $a \neq b \neq c$ and the axial angles are $\alpha \neq \beta \neq \gamma$. The examples are $K_2Cr_2O_7$, $CuSO_4.5H_2O$, H_3BO_3 Graphite, ZnO, CdS and HgS are hexagonal and $PbCO_3$ is orthorhombic.

28. What is the percentage of enantiomeric excess of a mixture containing 12.8 mol (R)-2-bromobutane and 3.2 mol (S)-2-bromobutane?

Accepted Answers

60 60.0 60.00

Solution:

$\text{Enantiomeric excess} = \text{moles (R)} - \text{moles(S)}$
= 12.8 – 3.2 = 9.6 mol

$$\text{Enantiomeric excess} = \frac{\text{Excess of one enantiomer over other}}{\text{Entire mixture}}$$

The percent enantiomeric excess can be calculated by dividing the excess (9.6 mol) of the R enantiomer by the total number of moles for both enantiomers.

$$\text{Enantiomeric excess} = \frac{9.6}{12.8 + 3.2} = 60\ \%$$

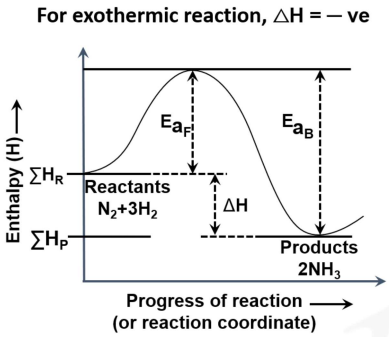
29. $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g); \Delta H = -22\, kcal$
Activation energy, E_a for the given reaction is $70\ kcal$. Find the activation energy for $2NH_3(g) \rightarrow N_2(g) + 3H_2(g)$ in $kcal$.

Accepted Answers

92 92.0 92.00

Solution:

The given reaction is an exothermic reaction since $\Delta H = -ve$



E_{a_F} =Activation energy of the forward reaction

E_{a_B}= Activation energy of the backward reaction

Enthalpy change can be expressed also in terms of activation energy,

$\Delta H = E_{a_F} - E_{a_B}$
$\Rightarrow -22 = 70 - E_{a_B}$
$\Rightarrow E_{a_B} = 92\ \text{kcal}$

30. The resistance of a conductivity cell containing $0.0001\ M\ KCl$ solution at $298\ K$ is $1500\ \Omega$
. What is the cell constant (in cm^{-1}) if conductivity of $0.0001\ M\ KCl$ solution at $298\ K$ is $0.146 \times 10^{-3}\ \text{S cm}^{-1}$.

Accepted Answers

0.219 0.21

Solution:

$$\text{Cell Constant} = \frac{\text{Conductivity}}{\text{Conductance}}$$
$$= \text{Conductivity} \times \text{Resistance}$$
$$= 0.146 \times 10^{-3} \times 1500 = 0.219\ \text{cm}^{-1}$$