Physics

1. **(c)** Both the electrons repel each other when they come closer to each other. So, the kinetic energy of the electron decreases due to repulsion and thus its potential energy increases.

2. **(b)** The situation can be digrameted as below.

The electric field $E = 100 Vm^{-1}$

For the downward motion of the particle of mass 1 kg .

$$mg\sin 45° - qE\cos 45° - \mu(mg\cos 45° + qE\sin 45°) = ma$$

$$\Rightarrow 1 \times 10 \times \frac{1}{\sqrt{2}} - \frac{1}{100} \times 100 \times \frac{1}{\sqrt{2}} - \frac{1}{10}$$

$$\left(1 \times 10 \times \frac{1}{\sqrt{2}} + \frac{1}{100} \times 100 \times \frac{1}{\sqrt{2}}\right) = 1 \times a$$

$$\Rightarrow \frac{10}{\sqrt{2}} - \frac{1}{\sqrt{2}} - \frac{1}{10}\left(\frac{10}{\sqrt{2}} + \frac{1}{\sqrt{2}}\right) = a$$

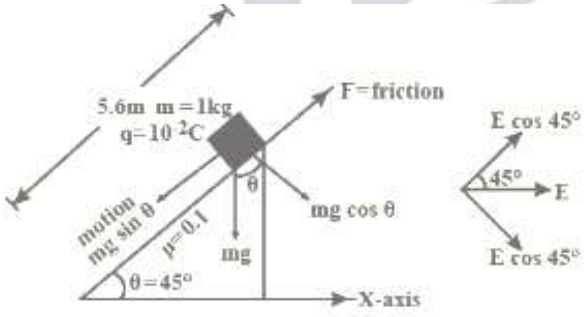
$$\Rightarrow \frac{10}{\sqrt{2}} - \frac{1}{\sqrt{2}} - \frac{1}{\sqrt{2}} - \frac{1}{10\sqrt{2}} = a$$

$$\Rightarrow a = \frac{79}{10\sqrt{2}} = \frac{7.9}{\sqrt{2}}$$

$$\Rightarrow a = 5.6\ m/s^2$$

Now, time taken by the particle to cover 5.6 m distance along the incline is

$$t = \sqrt{\frac{2S}{a}} = \sqrt{\frac{2 \times 5.6}{5.6}} = \sqrt{2} = 1.41\ s.$$



3. **(d)**

4. **(a)**

5. **(c)** Key Concept According to de-Broglie wavelength, the wave associated with moving particle is given by

$$\lambda = \frac{h}{mv}$$

where, m and v are the mass and velocity of the particle and h is Planck's constant.
de-Broglie wavelength of a particle, is given as

$$\lambda = \frac{h}{P} \Rightarrow \lambda \propto \frac{1}{P}$$
$$\Rightarrow \frac{\lambda_1}{\lambda_2} = \frac{P_2}{P_1} \text{ or } \frac{\lambda_\alpha}{\lambda_D} = \frac{P_D}{P_1}$$
$$\Rightarrow \frac{\lambda_\alpha}{\lambda_D} = \frac{2 \times 2\,V}{4 \times 2\,V} = \frac{4v}{4v}$$
$$\therefore \lambda_\alpha : \lambda_D = 1:1.$$

6. **(a)** de-Broglie wavelength $\lambda = \frac{h}{mv}$ Kinetic energy of the atom $K.E = \frac{1}{2}mv^2 = \frac{3}{2}KT \Rightarrow mv = \sqrt{3mKT}$
Thus we get $\lambda = \frac{h}{\sqrt{3mKT}}$

7. **(a)**

8. **(b)** Increasing order of wavelengths as given below γ - rays $<$ X - rays $>$ ultravoilet rays
Frequency order

$$\gamma - \text{ray} > X - \text{rays} > \text{ultravoilet rays}$$
$$\Rightarrow q > p > r$$

Thus, $q > p$

$$q > r$$
$$p > r$$

9. **(b)**

10. **(d)** Length of the smaller arc $l = r\theta$
So, resistance of the smaller arc $R_1 = \frac{r\theta}{2\pi r}R = \frac{\theta}{2\pi}R$
Resistance of bigger arc $R_2 = \frac{2\pi - \theta}{2\pi}R$
Since R_1 and R_2 are connected in parallel across AB.
Thus, equivalent resistance between A and B $\frac{1}{R_{AB}} = \frac{1}{R_1} + \frac{1}{R_2}$

$$\therefore \frac{1}{R_{AB}} = \frac{2\pi}{\theta R} + \frac{2\pi}{(2\pi - \theta)R}$$
$$\Rightarrow R_{AB} = \frac{R}{4\pi^2}(2\pi - \theta)\theta$$

So, option D is correct.

11. **(a)** We know,
Resistance is given as

$$R = \frac{\rho L}{A}$$

Now we can write

$$R_1 = \frac{\rho_1 L}{A}$$
$$R_2 = \frac{\rho_2 L_2}{A}$$

For the series combination we know,

$$R_{eq} = R_1 + R_2 = \frac{(\rho_1 + \rho_2)L}{A}$$

Or, we can write

$$\frac{\rho_{eq}\, 2L}{A} = \frac{(\rho_1 + \rho_2)L}{A}$$

Therefore,

$$\rho_{eq} = \frac{\rho_1 + \rho_2}{2}$$

12. (a) $a - q, b - r, c - p, d - s$

13. (d)

14. (d) As the law of refraction, we have,

$$\frac{\sin i_c}{\sin 90°} = \frac{1.5}{1.6}$$
$$\therefore \sin i_c = \frac{15}{16}$$
$$\Rightarrow i_c = \text{ Critical angle of medium A}$$
$$= \sin^{-1}\left(\frac{15}{16}\right).$$

15. (a) As radius of curvature of plane mirror is infinity So, its focus $f = \frac{R}{2}$ is also infinity. Now, power $= \frac{1}{f} = \frac{1}{\infty} = 0$.

16. (a) When a light wave travels from rarer medium to denser medium, its frequency remains the same but its wavelength decreases. Velocity of light waves decreases because of change in wavelength.

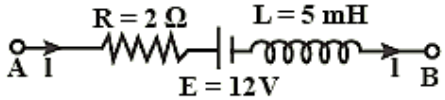
17. (a) The part of circuit is

Given, $\frac{dI}{dt} = 10^2 As^{-1}$

and $I = 2$ A

The voltage difference between point A and B

$$IR - 12 + L\frac{dI}{dt} = V_A - V_B$$
$$\Rightarrow 2 \times 2 - 12 + 5 \times 10^{-3} \times 10^3 = V_A - V_B$$
$$\Rightarrow 4 - 12 + 0.5 = -8.5 = V_A - V_B$$
$$\therefore V_B - V_A = -(-8.5) = 8.5 \text{ V}.$$



18. (b) Given $L = 10$ cm $= 0.1$mB $= 5 \times 10^{-4}$ Wb/m^{2}a $= 5$ m/s^2 Emf induced in the rod $E = BvL$ Rate of increase of induced emf $\frac{dE}{dt} = \frac{d}{dt}(BvL) = baL \Rightarrow \frac{dE}{dt} = 5 \times 10^{-4} \times 5 \times 0.1 = 2.5 \times 10^{-4}$ V/s

19. (d) Given : $v = \frac{25}{\pi}$ HzR $= 100\Omega$L $= 2$H

Inductive reactance $X_L = 2\pi vL = 2\pi \times \frac{25}{\pi} \times 2 = 100\Omega$

Using $\tan\phi = \frac{X_L}{R}$

$$\Rightarrow \tan\phi = \frac{100}{100} = 1$$
$$\Rightarrow \phi = 45°$$

20. (a) The correct option is **A** Leads the voltage by $\frac{\pi}{2}$ in phase

For a purely capacitive circuit current leads the voltage by $\pi/2$ in phase.

21. (a) Given,

$$V = 100\sqrt{2}\sin 100t \Rightarrow \omega = 100$$
$$C = 1\mu F$$

The peak voltage $V_O = 100\sqrt{2}$

$$\therefore \text{ rms voltage, } V_{rms} = \frac{V_o}{\sqrt{2}} = \frac{100\sqrt{2}}{\sqrt{2}} = 100 \text{ V}$$

As, current reading of the ammeter,

$$i = \frac{V_{rms}}{X_C} = \frac{V_{rms}}{\left(\frac{1}{\omega C}\right)}$$
$$= \frac{V}{\frac{1}{100 \times 1 \times 10^{-6}}}$$
$$= 100 \times 100 \times 10^{-6} = 10^{-2} \text{ A}$$
$$= 10^{-2} \times \frac{10}{10} = 10 \times 10^{-3} \text{ A}$$
$$= 10 \text{ mA}.$$

22. (c) At the distance of closest approach, r

$$K = \frac{1}{4\pi\varepsilon_0} \cdot \frac{2eZe^2}{K}$$
$$\because K = \frac{p^2}{2m}$$
$$\therefore r = \frac{4}{4\pi\varepsilon_0} \cdot \frac{2Ze^2}{\frac{p^2}{pm}}$$
$$\frac{1}{4\pi\varepsilon_0} \cdot \frac{4mZe^2}{p^2}$$

Thus, $r \propto \frac{1}{p^2}$

$$\therefore \frac{r_1}{r_2} = \frac{p_2^2}{p^2} = \frac{(2p)^2}{p^2}$$
$$\frac{r_1}{r_2} = \frac{4}{1} \Rightarrow \therefore r_2 = \frac{r_1}{4} = \frac{r}{4}$$

23. (b) A hydrogen atom has 6 spectral lines. Spectral emissions occurs when an electron transitions jumps from a higher energy state to a lower energy state. The spectral lines are grouped into series according to the lower energy level.

24. (d) We know that atomic number of the parent nucleus decreases by 2 and mass number decreases by 4 in each alpha decay whereas atomic number of the parent nucleus increases by 1 while mass number remains the same in each beta minus decay.

So atomic number of $X_4, Z = 72 + 2 \times 1 - 2 \times 2 = 70$

So mass number of $X_4, A = 180 - 2 \times 4 = 172$

25. (a) Let there is n number of fission per second produces a power of 6.4 W , then

$$n \times 200 \times 10^6 \times 1.6 \times 10^{-19}\ J/s = 6.4\ J/s$$
$$\therefore n = \frac{6.4}{200 \times 10^{-3} \times 1.6} = \frac{4}{2 \times 10^{-11}} = 2 \times 10^{11}.$$

26. (b) We know that atomic number of the parent nucleus decreases by 2 and mass number decreases by 4 in each alpha decay whereas atomic number of the parent nucleus increases by 1 while mass number remains the same in each beta minus decay.

Change in mass number $\Delta A = 238 - 206 = 32$

Number of alpha particles $N_\alpha = \frac{32}{4} = 8$

Decrease in mass number due to alpha decays only $= 2 \times 8 = 16$

Net decrease in mass number $\Delta Z = 92 - 82 = 10$

So increase in mass number due to beta particles $= 16 - 10 = 6$

Number of beta particles $N_\beta = \frac{6}{1} = 6$

27. (b)

28. (c) Let the initial intensity of the light be I_0.

Final intensity of the light $I = I_0 \cos^2\theta$

where $\theta = 60°$

$$\Rightarrow I = I_0 \times \cos^2 60° = 0.25 I_0$$

Percentage change in the initial and final intensities

$$= \frac{I_0 - I}{I_0} \times 100 = \frac{I_0 - 0.25 I_0}{I_0} \times 100 = 75\%$$

29. (b) Given: linear width of principle maximum = width of slit hence

$$\therefore (2\lambda/d)D = d$$

$$\therefore D = (d^2/2\lambda)$$

30. (c)

Charge flown $Q = ne = 10^{10} \times 1.6 \times 10^{-19} C = 1.6 \times 10^{-9} C$

Emitter current $I_E = \frac{Q}{t}$

$$I_E = \frac{1.6 \times 10^{-9}}{2 \times 10^{-6}} = 0.8 \times 10^{-3}\ A = 800 \mu A$$

31. (c)

32. (a) Two infinitely long equal wire carrying equal currents in same direction will attract each other.

33. (b) Both 8Ω resistors are connected in parallel to each other.

Equivalent resistance of two 8Ω resistors, $R' = \frac{8 \times 8}{8+8} = 4\Omega$

This 4Ω resistor is connected in series with 6Ω resistor.

Equivalent resistance of circuit $R_{eq} = 4 + 6 = 10\Omega$

Current flowing through 6Ω resistor, $I = \frac{V}{R_{eq}} = \frac{10}{10} = 1\ A$

Voltage across 6Ω resistor, $V_6 = 1 \times 6 = 6\ V$

34. (d) Galvanometer resistance $R_G = 50\Omega$
Series resistance initially $R_1 = 3950\Omega$
Voltage $V = 8$ V
Using $V = I_G(R_G + R_1)$

$\therefore 8 = I_G(50 + 3950)$
$\Rightarrow I_G = 0.002$ A

Now I_G is reduced to half of its initial value i.e. $I_G' = 0.001$ A

Using $V = I_G'(R_G + R_2)$
$\therefore 8 = (o.001)(50 + R_2)$
$\Rightarrow R_2 = 7950\Omega$

35. (c)

As, vertical component of Earth's magnetic field,

$B_V = \sqrt{3}\, B_H$

Angle of dip at any place is given by

$$\tan\delta = \frac{B_V}{B_H} = \frac{\sqrt{3}B_H}{B_H} = \sqrt{3}$$
$\Rightarrow \delta = \tan^{-1}(\sqrt{3}) = 60°.$

36. (a) The output of OR gate $A + B = Y$
The output of NOR gate

$\overline{A + B} = Y$

When, $A = B$, then

$\overline{A + A} = \overline{A} =$ NOT gate.

37. (a) The optical fibre is used in the frequency range of $1 - 1000$THz (microwave to ultraviolet). An optical fibre can offer a transmission band width in excess of 100 GHz.

38. (a) Key Concept Marconi antenna is a straight conductor of length equal to a quarter of the wavelength of radio signals to be transmitted or received i.e

$l = \lambda/4.$

It depends on frequency of carrier wave and directive of the beam etc.
Given, $v = 3 \times 10^3$ Hz
Now, speed of light, $c = v\lambda$

$\Rightarrow 3 \times 10^8 = 3 \times 10^3$ Hz $\cdot \lambda$
$\Rightarrow 10^5 = \lambda$

For minimum length of an antenna is

$$l = \frac{\lambda}{4} = \frac{10^5}{4} = 25000 \text{ m} = 25 \text{ km}.$$

39. (b) The volume of spheres.

$$27 \times \frac{4}{3}\pi r^3 = \frac{4}{3}\pi R^3$$

where, r and R are the volume of smaller and bigger sphere respectively.

$\Rightarrow R = 3r$

Now, initial potential of smaller sphere,

$$V_1 = \frac{1}{4}\pi\epsilon_0 \frac{Q}{r}$$
$$\therefore Q = V_1 r \times 4\pi\epsilon_0$$

$\therefore$ Charge on 27 spheres, we have

$$Q_T = 27 \times 10 \times r \times 4\pi\epsilon_0$$

Now, charge on bigger sphere

$$Q_B = V_2 R \times 4\pi\epsilon_0$$
$$\text{Now, } Q_T = Q_B$$
$$\Rightarrow 270 \times r \times 4\pi\epsilon_0 = V_2 R \times 4\pi\epsilon_0$$
$$\Rightarrow 270r = V_2 \times 3r \Rightarrow V_2 = 90 \text{ V}.$$

40. (a)

Chemistry

41. (d) Zone-refining is very useful for producing semiconductor and other metals of very high purity, e.g., germanium, silicon, boron, gallium and indium.

42. (b) Phosphine is formed in the reaction,

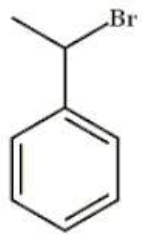
$$P_4 + 3NaOH + 3H_2O \rightarrow PH_3 + 3NaH_2PO_2$$

Sodium hydrophosphite is also one of the products of the reaction.

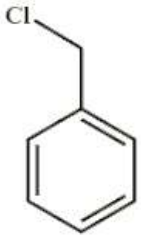
43. (c) The molecular formula for phosgene $= COCl_2$ Tear gas $= CCl_3NO_2$

44. (d) Aqua regia is the mixture of conc. HCl and conc. HNO_3 in the ratio of 3: 1.

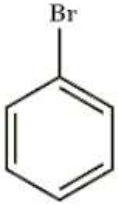
45. (d) Allylic halides are the compounds in which the halogen atom is bonded to sp^3 - hybridised carbon atom next to carbon-carbon double bond $(C = C)$.



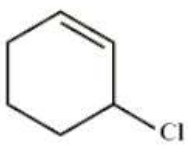
Benzylic halide



Benzylic halide



Aromatic



Allylic halide

46. (a) Dehydrohalogenation of CH_3CH_2Cl gives ethene (C_2H_4) as the main product as:

$$CH_3CH_2Cl + \text{ alc. } KOH \rightarrow C_2H_2 + KCl + H_2O$$

Molar mass of $CH_3CH_2Cl = 64.5$ g/mol and Molar mass of ethene $(C_2H_4) = 28$ g/mol

Number of moles of $CH_3CH_2Cl = \frac{6.45}{64.5} = 0.1$ mol

Since 1 mol of CH_3CH_2Cl will give 1 mol of ethene. However, only 50% of the reagent is used. So, only 50% of product will be formed.

$\therefore$ 0.05 mol of CH_3CH_2Cl will react to give 0.05 mol of ethene.

mass of ethene in 0.05 mol = moles x molecular wt.= $0.05 \text{ mol} \times 28 \text{ g/mol} = 1.4$ g

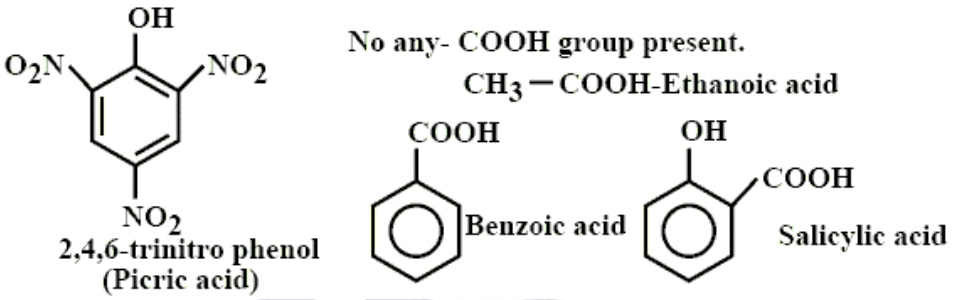
47. (a)

$$CH_3CH_2Cl + NaI \xrightarrow{\text{Acetone}} CH_3CH_2I + NaCl$$

This reaction is an example of halogen exchange which is known as finkelstein in which alkyl halide such as alklychloride / bromide reacts with NaI in the presence of acetone.

48. (a)

49. (a)



50.(a) Phenol does not react with Na_2CO_3 because it is weaker acid than carboxylic acid and thereby do not have the strength to substitute or give away its $H+$ ions to that of weak bases like sodium carbonate. Phenol is used for the preparation of aspirin which is used as an analgesic as well as antipyretic drugs.

Phenol is more soluble in water than chlorobenzene due to formation of H bond with water molecules. o-nitrophenol form intramolecular H -bonding while p -nitrophenol form intermolecular H -bonding. Due to this, nature o-nitrophenol has a lower boiling point than p-nitrophenol.

51. (c) The sum of powers of the concentrations of the reactants in the rate law expression is called the order of that chemical reaction

$X + Y \rightarrow XY$

The order of reaction with respect to X is 2.

$$\therefore -\frac{d[X]}{dt} = k[X]^2[Y]$$

Total order of reaction $= 2 + 1 = 3$

52. (a)

$X \xrightarrow{I} Y \xrightarrow{II}$, is a complex reaction.

Total order of reaction is 2 .
Molecularity of slowest step II is also 2 because for complex reaction, molecularity of the slowest step is same as the order of the overall reaction.

53. (b)

The correct option is **B** $k_1[ClO^-]^2$

I. $ClO^- + ClO^- \xrightarrow{K_3} ClO_2^- + Cl^-$ (Slow step)

II. $ClO_2^+ ClO^- \xrightarrow{k_2} ClO_3^- + Cl^-$ (Fast step)

Since, slowest step is the rate determining step. so the rate of reaction $= k_1[ClO^-]^2$.

54. (c) Under given conditions of temperature and pressure. NH_3 is easily liquefiable gas than H_2, N_2 and O_2. The higher the critical temperature, the more easily a gas is liquefied and hence more readily it will be adsorbed. As critical temperature increases, ease of liquefaction also increases and thus, adsorption increases.

55. (c) On dissolution, a large number of atoms or smaller molecules of a substance aggregate together to form species having a size in the colloidal range (1-1000 nm). The species thus formed are called multimolecular colloids. Sulphur sol consists of particles containing a thousand or more of S_8 sulphur molecules hence it is the multimolecular colloid.

56. (d) Adsorption leads to a decrease in the residual forces on the surface of the adsorbent. This causes a decrease in the surface energy of the adsorbent. Therefore, adsorption is always exothermic and ΔH is negative. And for reaction to occur ΔG should be negative so by equation $\Delta G = \Delta H - T\Delta S, \Delta S$ should be negative.

57. (d)

58. (b)

59. (a)

60. (a) In general, ligands can be arranged in the spectrochemical series in the order of increasing field strength as

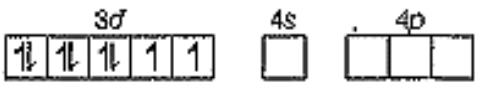
$SCN^- < F^- < NH_3 < en < CO$

61. (c)

$[NiCl_4]^{2-}$

$Ni^{2+} = 3\,d^8, 4\,s^\circ 4p^\circ$

In this complex, Cl is a weak ligand which does not pair the electrons. Therefore, two unpaired electrons are present in 3 d -orbital. hence, $[NiCl_4]^{2-}$ is paramagnetic in nature.



62. (a)

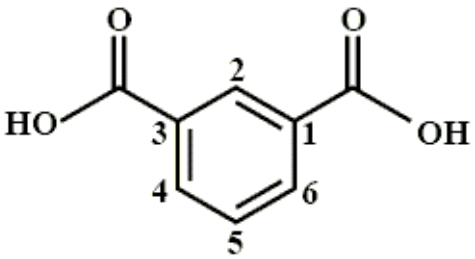
63. (c)

64. (b)

$CH_2 = CH - CHO$
Prop-2-enal
(Acrolein)

65. (b)

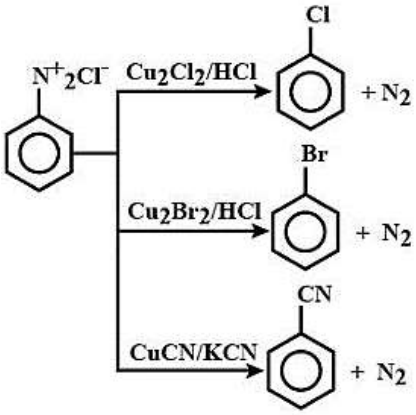
Isophthalic acid



Benzene-1, 3-dicarboxylic acid

66. (a)

67. (b) In sandmeyer's reaction Iodo Benzene cannot be formed because of its large size.



68. (c) Liver is not the source of Vitamin - B_1

69. (d) Amylopectin is a branched chain polymer of $\alpha - D$ - glucose units in which chain is formed by $C_1 - C_4$ glycosidic linkage whereas branching occurs by $C_1 - C_6$ glycosidic linkage.
Thus, amylopectin contains linkage between C_1 and C_4 and also between C_1 and C_6.

70. (b)

71. (b) Buna-S is used to bind pigmented coatings. It is the polymer derived from styrene and buta-diene.

72. (c) Salt of sorbic acid is used to prevent food from spoilage by microorganism.

73. (a) FeO shows metal deficiency defect. In crystal of FeO some Fe^{2+} cations are missing and the loss of positive charge is made up by the presence of required number of Fe^{3+} ions.

74. (d) MnO show antiferromagnetism having domain structure similar to ferromagnetic substance, but their domains are oppositively oriented and cancel out each other's magnetic moments.

75. (a)

76. (b)

77. (d) Osmotic pressure is widely used to determine molar masses of proteins, polymers and other macromolecules.

$$M_2 = \frac{w_2 RT}{\pi V}$$

where, π = osmotic pressure, R gas constant, V = volume of the solution (in L), M_2 = molar mass, w_2 = weight of solute

78. (b) During the electrolysis of aqueous sodium chloride solution, the products are $NaOH, Cl_2$ and H_2.

$$NaCl(aq) + H_2O(l) \rightarrow Na^+(aq) + OH^-(aq) + \frac{1}{2}H_2(g) + \frac{1}{2}Cl_2(g)$$

Due to formation of base, it turns res litmus into blue.

79. (a)

Metal	E°_{read}
A	0.34 V
B	-0.80 V
C	-0.46 V

A negative E° means that the redox couple is a stronger reducing agent than the H^+/H_2 couple and H_2. while a positive E° means that the redox couple is a weaker reducing agent than the H^+/H_2 couple, so correct order will be $B > C > A$

80. (d) Since, w=Zit

$$\text{or } \frac{(W)_{All}}{(W)_{All}} = \frac{(W)_{Ni}}{(W)_{Ni}} \Rightarrow \frac{\frac{18}{27}}{3} = \frac{\frac{(W)_{All}}{58.5}}{2}$$

$$\frac{18}{9} = \frac{2 \times (W)_{Ni}}{58.5}$$

$$\Rightarrow (W)_{Ni} = 58.5\ g$$

81. (d)
82. (a)
83. (b)
84. (a)
85. (c)
86. (c)
87. (a)
88. (c)
89. (a)
90. (b)
91. (c)
92. (a)
93. (d)
94. (a)
95. (b)
96. (a)
97. (a)
98. (a)
99. (a)
100. (b)
101. (b)
102. (a)
103. (d)
104. (a)
105. (c)
106. (c)
107. (d)

108. **(b)**
109. **(c)**
110. **(c)**
111. **(d)**
112. **(c)**
113. **(c)**
114. **(d)**
115. **(a)**
116. **(b)**
117. **(a)**
118. **(a)**
119. **(a)**
120. **(a)**