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Electric Field

1. Coulomb's law

$$F = \frac{1}{4\pi\epsilon}\frac{Q_1Q_2}{r^2}$$

2. Relative Permittivity

$$Relative\ permitivity = \frac{\epsilon}{\epsilon_0}$$
$$\epsilon_0 = permivitity\ of\ vacuum$$

3. Electric Field Intensity

$$\vec{E} = \frac{1}{4\pi\epsilon}\frac{Q}{r^2}$$

4. Force generated due to the electrical field intensity

$$F = \vec{E}q$$

5. Net electric flux (Gauss theorem)

$$\phi = \frac{Q}{\epsilon}$$

6. Electric Flux Density (equates to electrical field intensity)

$$\phi = \vec{E}A$$

$$\therefore \vec{E}A = \frac{Q}{\epsilon}$$

$$\begin{aligned} For\ a\ cylinder \\ \vec{E} &= \frac{1}{2\pi\epsilon}\frac{\lambda}{r} \\ For\ a\ conducting\ plate \\ \vec{E} &= \frac{\sigma}{\epsilon} \\ For\ an\ insulating\ plate \\ \vec{E} &= \frac{\sigma}{2\epsilon} \\ For parallel\ plate\ capacitors, \\ \vec{E} &= \frac{Q}{A\epsilon} \end{aligned}$$

7. Electric Potential

$$V = \frac{1}{4\pi\epsilon}\frac{Q}{r}$$
$$V = \vec{E}r$$

8. Potential Difference

$$V_{AB} = \delta v = \frac{Q}{4\pi\epsilon}(\frac{1}{a} - \frac{1}{b})$$

9. Electric Potential Energy (workdone)

$$E_p = \delta vq$$

10. Potential gradient (equals to negative value of electric field intensity)

$$P_g = (\frac{\delta v}{\delta d})$$

$$\vec{E} = -(\frac{\delta v}{\delta d})$$

11. Static electric capacitance

$$Q = CV_s$$

$$\begin{aligned} &For\ spherical\ conductor, \\ &C = 4\pi\epsilon R \\ &For\ parallel\ plate\ capacitors, \\ &C = \frac{A\epsilon}{d} \\ &Capacitors\ in\ series\ connection, \\ &\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} \\ &Capacitors\ in\ parallel\ connection, \\ &C = C_1 + C_2 \\ &Capacitror\ with\ 2\ dielectric\ media\ -in\ series, \\ &C = \frac{A\epsilon_1\epsilon_2}{d_1\epsilon_2 + d_2\epsilon_1} \\ &Capacitror\ with\ 2\ dielectric\ media\ -in\ parallel, \\ &C = \frac{A_1\epsilon_1 + A_2\epsilon_2}{d} \end{aligned}$$

12. Static electric potential energy

$$E_p = \frac{1}{2}V_sQ = \frac{1}{2}CV_s^2 = \frac{1}{2}\frac{Q^2}{V_s}$$

Gravitational Field

1. Newtons Law of Gravitation

$$F = \frac{Gm_1m_2}{r^2}$$

2. Gravitational Field Intensity

$$g = \frac{GM}{r^2}$$

3. Gravitational Potential

$$U = -\frac{GM}{r}$$

4. Gravitational Potential Energy

$$E_p = -mgr = Um$$

5. Velocity of an artificial satellite

$$v = \sqrt{\frac{GM}{r}}$$

6. Angular velocity of an artificial satellite

$$\omega = \sqrt{\frac{GM}{r^3}}$$

7. Time period of an artificial satellite

$$T = 2\pi\sqrt{\frac{r^3}{GM}}$$

8. Total energy of an satellite

$$E_T = E_k + E_p$$
$$E_T = \frac{1}{2}m\frac{GM}{r} - \frac{GMm}{r}$$
$$E_T = \frac{GMm}{r}$$

9. Minimum energy

$$E_{min} = GMm(\frac{1}{R} - \frac{1}{r})$$

10. Escape Velocity

$$v_{esc} = \sqrt{\frac{2GM}{R}}$$

Heat

1. Triple point of water

$$1K = \frac{Temperature\ of\ triple\ point\ of\ water}{273.16}$$

2. Solid Expansion

$$
\begin{aligned}
\delta l_2 =& l_1(1+\theta\alpha) \\
\delta A_2 =& A_1(1+\theta\beta) \\
\delta V_2 =& V_1(1+\theta\gamma)
\end{aligned}
$$

3. Liquid Expansion

$$r = r_R + 3\alpha$$

4. Density variation with temperature

$$\rho_2 = \frac{\rho_1}{(1+3\alpha\theta)}$$

5. Boyle's Law - Only for idea gasses

$$P_1V_1 = P_2V_2$$

6. Charles's Law- Only for idea gasses

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

7. Volume expansion of gasses (Under constant pressure)

$$V = V_o(1+\gamma_p\theta) \rightarrow \gamma_p = 0.003^0C$$

8. Pressure Law - Only for idea gasses

$$\frac{P_1}{T_1} = \frac{P_2}{T_2}$$

9. Combined gas equation

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

10. Ideal gas equation

$$PV = nRT$$

$$Other\ forms,$$

$$
\begin{aligned}
PV &= \frac{m}{M}RT \\
\frac{P}{\rho} &= \frac{RT}{M}
\end{aligned}
$$

11. Avogadro Law - for any gass

$$\frac{V}{N} = k$$
$$(N = nL)$$

12. Dalton's Law of partial pressure.

$$P_T = P_A + P_B + P_C$$

13. Kinetic theory equations (optional forms)

$$For\ a\ molecule,$$

$$PV = \frac{1}{3} N m_o \bar{c^2}$$

$$For\ a\ gass,$$

$$PV = \frac{1}{3} m \bar{c^2}$$

$$P = \frac{1}{3} \rho \bar{c^2}$$

14. Relationship between root mean square and absolute temperature

$$c = \sqrt{\frac{3RT}{M}}$$

15. Kinetic energy of gas molecule

$$E_K = (\frac{3}{2})(\frac{R}{L})T$$

$$\frac{R}{L} = Boltzman\ Constant(K)$$

$$\therefore E_K = \frac{3}{2} KT$$

16. Relative Humidity

$$In\ terms\ of\ vapour\ density,$$

$$R.H = \frac{\rho}{\rho_s} * 100\%$$

$$In\ terms\ of\ vapour\ mass(constant\ volume),$$

$$R.H = \frac{m}{m_s} * 100\%$$

$$In\ terms\ of\ vapour\ pressure,$$

$$R.H = \frac{P}{P_s} * 100\%$$

$$In\ terms\ of\ dew\ point,$$

$$R.H = \frac{S.V.P\ @\ \theta_D}{S.V.P\ @\ \theta_R} = \frac{P_{SD}}{P_{SR}} * 100\%$$

$$In\ terms\ of\ absolute\ humidity,$$

$$R.H = \frac{A.H\ @\ \theta_R}{A.H\ @\ \theta_D} = \frac{P_R}{P_D} * 100\%$$

17. Heat capacity

$$H = C\theta$$

18. Specific Heat Capacity

$$H = mS\theta$$

19. Molar Heat Capacity

$$H = nC_0\theta$$

20. Relationship between molar heat capacity and Molar mass

$$C_o = MS$$

21. Specific Latent Heat

$$H = mL$$

22. Relationship between Molar heat capacity under constant pressure and constant volume

$$C_p - C_v = P\delta V$$

23. Workdone by a gas

$$\begin{aligned} For\ a\ whole\ gas, \\ W &= P\delta V \\ For\ a\ 1\ mole\ of\ gas, \\ W_o &= C_p - C_v \end{aligned}$$

24. Relationship between Molar heat capacity under constant pressure, constant volume and universal gas constant

$$C_p - C_v = R$$

25. Relationship between specific heat capacity under constant pressure, constant volume and universal gas constant

$$S_p - S_V = \frac{R}{M}$$

26. Atomicity

$$Atomicity(\gamma) = \frac{S_p}{S_v} = \frac{C_p}{C_v}$$

27. First law of thermodynamics

$$\delta Q = \delta U + \delta W$$

$$\begin{aligned} When\ work\ is\ done\ by\ the\ gas, \\ \delta Q &= \delta U + \delta W \\ When\ work\ is\ done\ on\ the\ gas, \\ \delta Q &= \delta U - \delta W \end{aligned}$$

28. Thermodynamic processes

$$
\begin{aligned}
&Isothermal\ process(\delta T = 0), \\
&\delta Q = \delta W \\
&\rightarrow P_1V_1 = P_2V_2 \\
&Adiabatic\ process(\delta Q = 0), \\
&\delta U = -\delta W \\
&\delta U = -P\delta V \\
&\rightarrow \frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2} \\
&Isobaric\ process(\delta P = 0), \\
&\delta Q = \delta U + \delta W \\
&\rightarrow \frac{V_1}{T_1} = \frac{V_2}{T_2} \\
&Isochoric\ process(\delta V = 0), \\
&\delta Q = \delta U \\
&\rightarrow \frac{P_1}{T_1} = \frac{P_2}{T_2}
\end{aligned}
$$

29. PV curves

$$Area\ under\ the\ graph = Workdone = P\delta V$$

$$
\begin{aligned}
Clockwise\ process &\rightarrow +W \\
Anti-clockwise\ process &\rightarrow -W
\end{aligned}
$$

30. Excess Temperature

$$\theta_E = \theta_S - \theta_R$$

31. Rate of loosing heat

$$\frac{dH}{dt} = KA(\theta_S - \theta_R)$$

32. Rate of cooling

$$\frac{d\theta}{dt} = \frac{KA}{mS}(\theta_S - \theta_R)$$

$$Rate\ of\ cooling = \frac{Rate\ of\ loosing\ heat}{mS}$$

33. Cooling Curve

$$Gradient\ of\ the\ graph = Rate\ of\ Cooling = \frac{d\theta}{dt}$$

Magnetic Field

1. Magnetic Flux Density

$$B = \frac{\phi}{A}$$

2. Force generated on a linear current carrying conductor placed in an magnetic field

$$F = BILSin(\theta)$$

$$B \rightarrow Magnetic\ Flux$$
$$L \rightarrow Length\ of\ the\ conductor$$
$$I \rightarrow Current$$
$$\theta \rightarrow angle\ with\ the\ horizontal$$

3. Force generated of a square loop which carries current with number of turns

$$F = BINACos(\theta)$$

$$A \rightarrow Area$$
$$N \rightarrow Number\ of\ turns$$

4. Current sensitivity of Ammeter

$$\frac{BNA}{k} = \frac{\theta}{I}$$

5. Voltage sensitivity of Ammeter

$$\frac{BNA}{kR} = \frac{\theta}{V}$$

6. Force on a charge particle moving in a magnetic field

$$F = Bq\vec{u}Sin(\theta)$$

$$q \rightarrow charge$$
$$\vec{u} \rightarrow drift\ velocity$$
$$\theta \rightarrow angle\ with\ the\ horizontal$$

7. Bio-Savat laws

$$Around\ a\ straight\ coductor\ with\ finite\ length$$
$$B = \frac{\mu_o I}{4\pi r}(Sin(\alpha_1) + Sin(\alpha_2))$$

$$Around\ a\ straight\ coductor\ with\ infinite\ length$$
$$B = \frac{\mu_o I}{2\pi r}$$

$$At\ the\ center\ of\ a\ circular\ loop$$
$$B = \frac{\mu_o I}{2r}$$

$$At\ the\ center\ of\ a\ circular\ loop\ with\ N\ turns$$
$$B = \frac{\mu_o IN}{2r}$$

$$Through\ a\ solonoid\ with\ N\ turns$$
$$B = \mu_o IN$$

8. Hall voltage

$$V_H = B\vec{u}d = \frac{BI}{ten}$$

Current Electricity

1. Current

$$I = \frac{Q}{t}$$

2. Current Density

$$J = \frac{I}{A}$$

3. Mean Drift Velocity

$$\vec{u} = \frac{I}{Ane}$$

4. Ohm's Law

$$V = IR$$

5. Electric Resistance

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

6. Conductivity

$$C = \frac{1}{\rho}$$

7. Resistance variation with temperature

$$R = R_o(1 + \alpha\theta)$$

8. Resistor networks

$$Series\ network,$$
$$R = R_1 + R_2 + R_3$$

$$Parallel\ network,$$
$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

9. Root-mean-square for current and voltage (Used in AC current)

$$V_s \rightarrow peak\ voltage$$
$$I_s \rightarrow peak\ current$$

$$V_{r.m.s} = \frac{V_s}{\sqrt{2}}$$
$$I_{r.m.s} = \frac{I_s}{\sqrt{2}}$$

10. Electrical Energy

$$E = VQ = VIt = I^2Rt = \frac{V^2t}{R}$$

11. Electric Power

$$P = \frac{VQ}{t} = VI = I^2R = \frac{V^2}{R}$$

12. Effective potential of a cell with internal resistance.

$$When\ current\ leaving\ (+)\ terminal,$$
$$V = E - Ir$$

$$When\ current\ is\ leaving\ (-)\ terminal,$$
$$V = E + Ir$$

13. Effective electromotive force of a cell network

$$Series\ Network,$$
$$E = E_1 + E_2 + E_3$$
$$r = r_1 + r_2 + r_3\ (internal\ resistance)$$

$$Parallel\ Network,$$
$$\frac{E}{r} = \frac{E_1}{r_1} + \frac{E_2}{r_2} + \frac{E_3}{r_3}$$

14. Kirchhoff's laws

$$KCL,$$
$$\Sigma I_{in} = \Sigma I_{out}$$

$$KVL,$$
$$\Sigma E = \Sigma IR$$

15. Energy concept of a simple cell.

$$Power\ of\ cell = Total\ power\ of\ resistors$$

16. Efficiency of a circuit. (Maximum power is given when r = R)

$$Efficiency = \frac{Power\ of\ external\ resistance}{Power\ of\ cell} * 100\%$$

$$\eta = \frac{R}{R+r} * 100\%$$

17. Wheatstone bridge

$$\frac{R_1}{R_2} = \frac{R_3}{R_4}$$

18. Meter Bridge

$$l \rightarrow balance\ length$$

$$\frac{R_1}{R_2} = \frac{l}{100-l}$$

19. Potentiometer

$$l \rightarrow balance\ length$$
$$K \rightarrow Potential\ Gradient$$

$$E = Kl$$
$$K = \frac{IR}{l}$$

Matter and Radiation

1. Speed of an electromagnetic wave

$$\epsilon \rightarrow Permitivity$$
$$\mu \rightarrow Permiability$$

$$C = \frac{1}{\sqrt{\epsilon\mu}}$$

2. Surface emissivity

$$e = \frac{Total\ energy\ emitted\ by\ a\ surface}{Energy\ emitted\ by\ a\ black\ body\ with\ same\ surface\ area}$$

$$For\ black\ body \rightarrow e = 1$$

3. Surface absorptivity

$$a = \frac{Energy\ absorbed\ by\ a\ surface}{Energy\ falls\ on\ that\ surface}$$

$$For\ black\ body \rightarrow a = 1$$

4. Intensity of sound

$$I = \frac{E}{At}$$

5. Stefan's Law

$$I = \sigma T^4$$
$$E = eAt\sigma T^4$$
$$For\ black\ body \rightarrow E = At\sigma T^4$$

6. Wien's Displacement Law

$$C \rightarrow Wien's\ Constant$$
$$\frac{1}{\lambda_m} \propto T$$

$$C = \lambda_m T$$

7. Planck-Einstein relation

$$h \rightarrow Planck's\ constant$$

$$E = hf$$

8. Photoelectric effect

$$I_{max} \propto Intensity$$
$$V_s \propto frequency$$

$$Intensity = \frac{ne}{t}$$

9. Einstein's Hypothesis on photoelectric effect

$$\phi \rightarrow work\ function$$
$$f_o \rightarrow threshhold\ frequency$$
$$e \rightarrow charge\ of\ an\ electron$$
$$V_s \rightarrow Stop\ potential$$

$$hf = \phi + K.E_{max}$$
$$hf = hf_o + \frac{1}{2}mv^2$$

$$hf = hf_o + eV_s$$

10. Work function

$$c \rightarrow Speed\ of\ light$$
$$\phi = \frac{hc}{\lambda}$$

11. De Broglie Wave length

$$p \rightarrow momentum$$

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

12. X-ray tube (work done to move a charge b/w terminals)

$$eV = hf$$

13. α decay

$$\alpha\ particle \rightarrow ^4_2\ \alpha$$

$$^b_aX \rightarrow ^{(b-4)}_{(a-2)}Y +\ ^4_2\alpha + Energy$$

14. β^- decay

$$\beta^-\ particle \rightarrow ^0_{-1}\ \beta$$
$$\vec{V}_e \rightarrow Anti - electro\ neutrino$$

$$^b_aX \rightarrow ^{(b)}_{(a+1)}Y +\ ^0_{-1}\beta + \vec{V}_e$$

$$1\ neutron\ converts\ to\ 1\ proton$$

15. β^+ decay

$$\beta^+\ particle \rightarrow ^0_{+1}\ \beta$$
$$V_e \rightarrow electro\ neutrino$$

$$^b_aX \rightarrow ^{(b)}_{(a-1)}Y +\ ^0_1\beta + V_e$$

$$1\ proton\ converts\ to\ 1\ neutron$$

16. Rate of disintegration

$$\frac{dN}{dt} = -\lambda N$$
$$N = N_o e^{-\lambda t}$$

17. Activity of radioactive sample

$$A = \lambda N$$

18. Half life of an atom

$$T\frac{1}{2} = \frac{0.7}{\lambda}$$

Elasticity

1. Stress

$$\sigma = \frac{F}{A}$$

2. Strain

$$\epsilon = \frac{e}{l}$$

3. Hook's Law

$$\gamma = \frac{Stres}{Strain} = \frac{\sigma}{\epsilon}$$

$$\frac{F}{A} = \gamma\frac{e}{l}$$

4. Elastic Strain Energy

$$E_o = \frac{1}{2} * Tension * Extension$$

$$E_o = \frac{1}{2} * Stress * Strain$$

5. Force on a rod when expansion or compression is prevented

$$F = \gamma A\alpha(\delta\theta)$$

Viscosity

1. Newtons Law of viscosity (viscose b/w 2 liquid layers moving at `v1` and `v2`)

$$F = \eta A\frac{(v_1 - v_2)}{d}$$

$$\eta \rightarrow coefficient\ of\ viscosity$$

2. Stock's Law (viscose force on a spherical object with radius `r` and speed `v`)

$$F = 6\pi r\eta v$$

3. Acceleration of a small spherical object falling in a liquid medium

$$\frac{(\sigma - \rho)g}{\sigma} - \frac{9\eta v}{2r^2\sigma} = a$$

$$\begin{aligned} r &\rightarrow radius\ of\ the\ sphere \\ \sigma &\rightarrow density\ of\ the\ sphere \\ \rho &\rightarrow density\ of\ the\ liquid \\ v &\rightarrow velocity\ of\ the\ sphere \end{aligned}$$

4. Terminal Velocity

$$v = \frac{2r^2 g(\sigma - \rho)}{9\eta}$$

5. Poiseuille's Equation (Rate of volume flow through a steady flow of fluid)

$$\frac{v}{t} = \frac{\pi}{8} \frac{\delta P}{l} \frac{r^4}{\eta}$$