Summary of Chapter 16 – Electrical Energy and Capacitance

Please read Chapter 16 carefully, and make sure that you understand the summary points below.

► The **difference in electric potential** between two points, A and B, is

$$V_B - V_A = \frac{\Delta(PE)}{q}$$

where Δ(PE) is the *change* in electrical potential energy experienced by a charge, q, as it moves from A to B. The units of potential difference are joules per coulomb, or **volts**; 1 J/C = 1 V.

► The **electric potential difference** between two points, A and B, in a uniform electric field, E, is

$$V_B - V_A = -Ed$$

where d is the distance between A and B, and E is the strength of the electric field in that region.

► The **electric potential** due to a point charge, q, at distance r from the point charge is

$$V = k\frac{q}{r}$$

► The **electrical potential energy** of a pair of point charges separated by distance r is

$$PE = k\frac{q_1 q_2}{r}$$

► Every point on the surface of a charged conductor in electrostatic equilibrium is at the same potential. Firthermore, the potential is constant everywhere inside the conductor and equal its value on the surface.

► The **electron volt** is defined as the energy that an electron (or proton) gains when accelerated through a potential difference of 1 V. The conversion between electron volts and joules is 1 eV = 1.602×10^{-19} joules.

► A **capacitor** consists of two metal plates with charges that are equal in magnitude but opposite in sign. The **capacitance** (C) of any capacitor is the ratio of the magnitude of the charge, Q, on either plate to the potential difference, ΔV, between them:

$$C = \frac{Q}{\Delta V}$$

Capacitance has the units coulombs per volt, or **farads**; 1 C/V = 1 F.

► The capacitance of two *parallel metal plates* of area A separated by distance d is

$$C = \varepsilon_0 \frac{A}{d}$$

where ε_o is a constant called the **permittivity of free space**, with the value 8.85×10^{-12} C^2/Nm^2.

► The equivalent capacitance of **parallel capacitors** is

$$C_{eq} = C_1 + C_2 + C_3 + \cdots$$

and the equivalent capacitance of **series capacitors** is

$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \cdots$$

► Three equivalent expressions for calculating the **energy stored** in a charged capacitor are

$$\text{Energy stored} = \tfrac{1}{2}Q\Delta V = \tfrac{1}{2}C(\Delta V)^2 = \frac{Q^2}{2C}$$

► When a nonconducting material, called a **dielectric**, is placed between the plates of a capacitor, the capacitance is multiplied by the factor κ, which is called the **dielectric constant** and is a property of the dielectric material. The capacitance of a parallel-plate capacitor filled with a dielectric is $\kappa\varepsilon_0 A/d$.