NATIONAL BUSINESS AND TECHNICAL EXAMINATIONS BOARD NATIONAL TECHNICAL CERTIFICATE EXAMINATION

QUESTION 1

BASIC ELECTRICITY

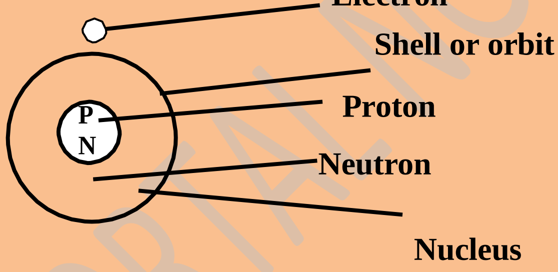
1(a) Explain the following terms in relation to atomic structure

(i) Proton
(ii) Neutron
(iii) Electron

(b) Three cells of emf 1.5 volts with an internal resistance of 2Ω each are connected in series to an external resistance of 3Ω. Calculate

(i) total electromotive force of the battery
(ii) current flowing through the 3Ω

SOLUTION

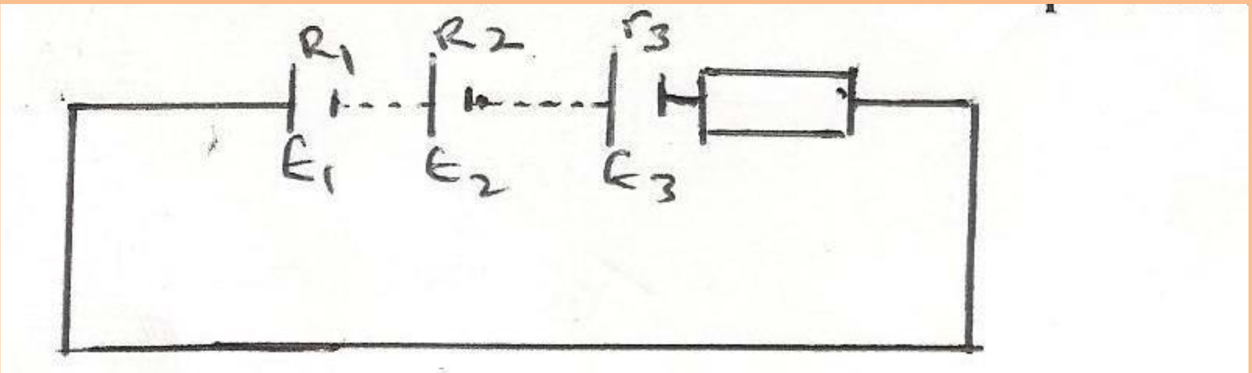


a.i. The proton is the positively charged elementary particle that forms the nucleus of an atom. It is about 18836 times heavier than the electron. It is a stable unit charge of mass 1.67 $\times 10^{-27}$kg. For a neutral atom the number of protons is always equal to the number of electron.

a(ii) The neutron is also an elementary particle in an atom, having zero charge and rest mass of 1.67492 x 10^{-27}kg. It is a constituent of the atomic nucleus of an atom. Both the neutron and the proton for ms the central massive part of the atom called the nucleus

a(iii) The Electron is the negatively charged elementary particles found on the shell or orbit of the atom. It has charge of 1.602192 $\times 10^{-19}$ coulombs and a mass of 9.10956 x 10^{-31}kg. The number of electrons is equal to the number of protons in a neutral atom.

1b.



Total internal resistance, r_T = $r_1 + r_2 + r_2$

= 2+2+2

∴ r_T = 6Ω

(i) Total emf, = $E_1 + E_2 + E_3$ (series)

= 15. +1.5. +1.5.

= 4.5V

total resistance in the circuit is

R_T = $R + r_T$

3+6

= 9Ω

(ii) Current in the circuit = the current through the 3Ω resistor

$I = \frac{E}{R+r}$

$= \frac{4.5}{3+6} = \frac{4.5}{9}$

$I = \frac{4.5}{9} = 0.50A$

∴ I = 0.50A

This is the current through the 3Ω resistor

QUESTION 2

2. (a) Define the following and give TWO examples of each

(i) Insulator

(ii) Conductor

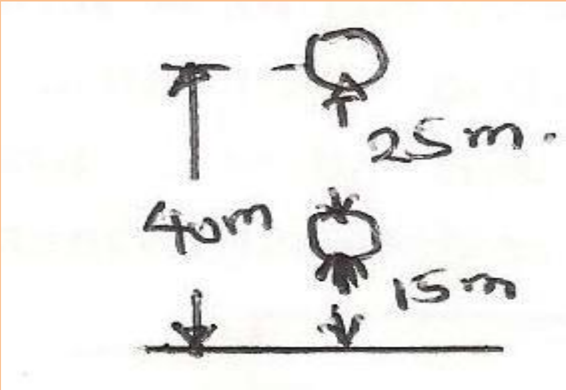
(b) An orange of mass 50g falls from rest from a height of 40m. Calculate the kinetic energy of the orange after falling a distance of 25m. (Neglect air resistance Take g = $10m/S^2$).

SOLUTION

2(a) (i) An insulator is a material that does not allow electrons to pass through it freely. It is therefore a non-conductor of heat and electricity. Examples are plastic, wood, paper, silk, wool, e.t.c.

(ii) A conductor is a material that allows charges to pass through it freely. It is therefore called conductor of heat and electricity. Examples are metals, the human body, the earth, electrolytes, e.t.c.

2(b)



mass = 50g = 50×100^{-3}kg

U = O

v = g

g = $10ms^{-2}$

h = 40m

$$s = ut + \frac{1}{2}gt^2$$

$$S = O + \frac{1}{2}gt^2$$

$$t^2 = \frac{2s}{g}$$

$$t = \sqrt{\frac{2s}{g}} = \sqrt{\frac{2x25}{10}}$$

$$= \sqrt{5}$$

$$\therefore \quad t = 2.24s$$

But $v = U + gt$

$= O + 10 \times 2.24$

$= \underline{\underline{22.4ms^{-1}}}$

OR

$V^2 = u^2 + 2gh$

$V^2 = O + 2x10x25$

$V^2 = 500$

$V = \sqrt{500}$

$= \underline{\underline{22.4ms^{-1}}}$

K.E. $= \frac{1}{2}mv^2$

$= \frac{1}{2} x50x10^{-3} \times (22.4)^2$

$= 25x501.76x10^{-3}$

$= 12544x1v^{-3}$

$= \underline{\underline{12.5J}}$

Question3

3. (a) What is a Resistor? Give its symbol

(b) List THREE types of Resistors

(c) Three resistors of values 15Ω, 20Ω and 30Ω are connected in series. If a voltmeter connected across the 20Ω resistor reads 90V, calculate:

(i) total resistance of the circuit

(ii) current in the 30Ω resistor

(iii) Voltage drop in the 15Ω resistor

(iv) Power consumed by the circuit

SOLUTION

3(a) Resistor is an electrical component or electrical conductor which is constructed to have a precise or definite value of resistance. As an electrical component, it forms opposition to the free flow of electric current. Resistor is made with a length of resistance wire such as constantan and Nichrome. the symbol of a resistor is given as

(b) Types of Resistors

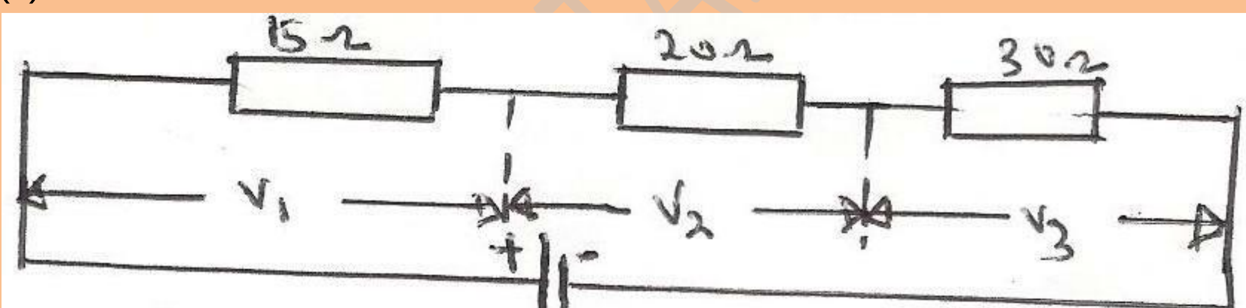
(i) Wire-wound Resistor (Fixed Resistor)

(ii) Moulded -carbon Resistor

(iii) Rheostat/potentiometer/variable Resistor

(iv) High stability resistor (carob film Resistor

(c)



(i) Total Resistance R_T

R_T = $R_1 + R_2 + R_3$ (series)

= 15 + 20 + 30

= 65Ω

(ii) Current in the 30Ω resistor. The current across the three resistors 15Ω, 20Ω and 30Ω is the same because they are in series.

Current in the 20Ω resistor of voltage drop 90V is

$$I = \frac{V_2}{R_2} = \frac{90}{20} = 4.5A$$

$I = 4.5A$

⟹ Current in the 30Ω resistor is 4.5A

(iii) Voltage drop, V_1 in the 15Ω resistor

$V_1 = IR_1 = 4.5 \times 15$

$\underline{67.5V}$

Similarly, the voltage drop in the 30Ω resistor is

$V_3 = IR_3 = 4.5 \times 30 = 135v$

$\therefore$ Total p.d, $V_T = V_1 + V_2 + V_3$

$= 67.5 + 90 + 135$

$= \underline{\underline{2}}92.5v$

(iv) Power consumed by the circuit is P

$P = IV$ or V^2/R or I^2R

$P = IV = 4.5 \times 292.5 = 1316.25W$

$= V^2/R = \frac{(292.5)^2}{65} = 1316.25W$

$= I^2R = (4.5)^2 \times 65 = 1316.25W$

Question 4

4. (a) Define capacitance and state its unit of measurement

(b) Enumerate FOUR types of capacitors

(c) Three capacitors of values 5μf, 15μf and 30μf are connected in series. Another capacitor of value 50μf is connected in parallel with the series group across a 200V d.c. source. Calculate.

(i) total capacitance of the series group

(ii) total capacitance of the circuit

(iii) total charge stored in the capacitor

(iv) energy stored by the 50μf capacitor

Solution

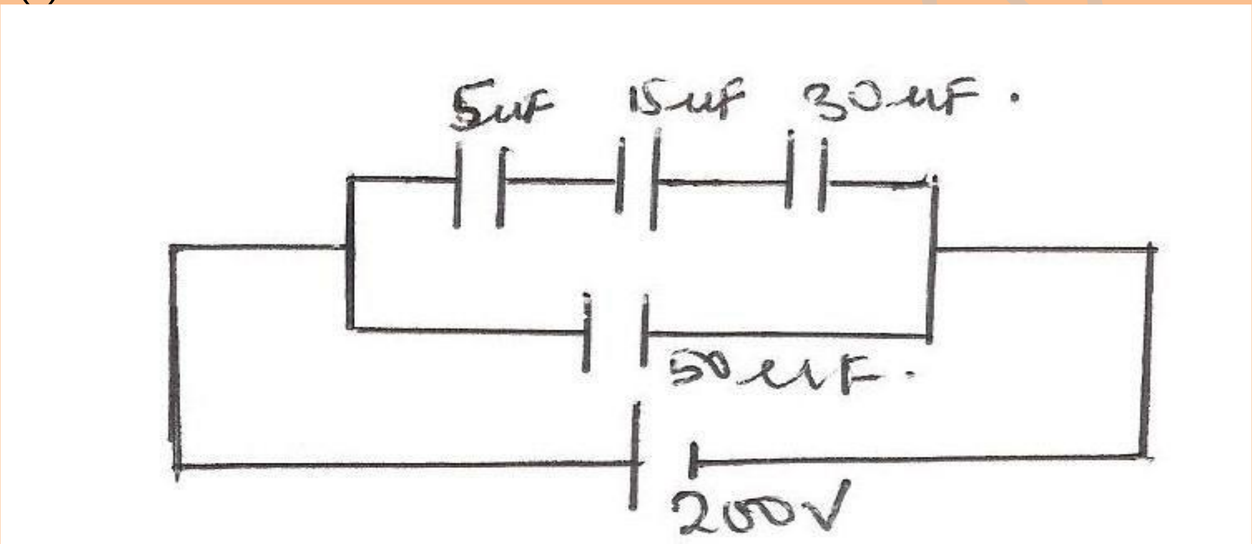
4a. The ability of a capacitor to store electric charges is known as capacitance. It can also be defined as the ratio of the amount of electricity (charge), Q transferred from one plate to the other, to the potential difference produced between the plates. The symbol is C and it is given as $C = Q/V$

The unit of measurement of the capacitance is Farad F (coulomb per volt).

4(b) Types of Capacitors

(i) Paper capacitor
(ii) Electrolytic capacitor
(iii) Ceramic capacitor
(iv) Silver mica capacitor
(v) Plyester capacitor & poly carbonate capacitor
(vi) Tantalum capacitor
(vii) Polystyrene capacitor

4(c)



(i) Total capacitor in series group

$$\frac{I}{C_s} = \frac{I}{C_1} + \frac{I}{C_2} + \frac{I}{C_3}$$

$$= \frac{6 + 2 + 1}{30}$$

$$= \frac{9}{30}$$

$$\Longrightarrow C_s = \frac{30}{9} = 3.33$$

$$\therefore C_s = \underline{\underline{3.33\mu f}}$$

(ii) Total capacitance of the circuit

$$C_T = C_s + C$$

$$= 3.33 + 50$$

$$\underline{\underline{53.33\mu f}}$$

(iii) Total charge stored in the capacitor

Q_T = C_TV

= 53.33 x 200

= 1066μC or 1066 x 10^{-6} or 1.07 x 10^{-2}C

(iv) Energy stored by the 50μf capacitor.

W = ½ C V^2

= ½ x 50μf x $(200)^2$

= 25 x 40000 x 10^{-6}J

= 1000 000 X 10^{-6}J = 1.0J

Question 5

5 (a) Define the following terms in relation to alternating current and state their symbols

(i) inductive reactance

(ii) impedance

(b) A 200μf capacitor is connected in series with a 60Ω resistor. The combinations is connected to a 200V, 50Hz supply. Calculate:

(i) capacitive reactance of the capacitor

(ii) inpendance of the circuit

(iii) current

(iv) power factor

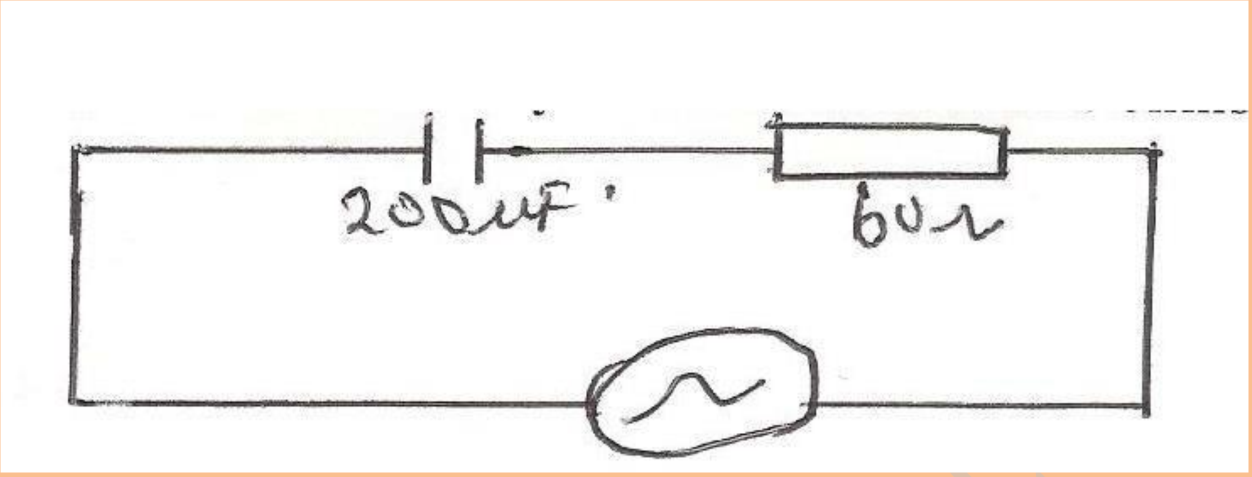
Solution

5a(i) Inductive Reactance is the opposition to alternating current due to the presence of an inductor in the circuit. It is given as X_L and can be obtained from the relationship that, $X_L = 2\pi fL$. The symbol is X_L and its unit is ohms.

a(ii) Impedance is the effective or total opposition to alternating current due to the presence of an inductance coil (an inductor), the capacitor and a resistor in an A.C. circuit.

The impedance is represented with a symbol Z and its unit is ohms.

5(b)



(i) Capacitive reactance of the capacitor

$$X_c = \frac{1}{2\pi fc}$$

$$= \frac{1 \times 10^6}{2 \times 3.142 \times 50 \times 200}$$

$$= \frac{10^6}{62840}$$

$$= 15.91\Omega$$

(ii) Impedance of the circuit

$$Z = \sqrt{R^2 + (Xc)^2}$$

$$= \sqrt{60^2 + (15.91)^2}$$

$$= \sqrt{60^2 + (15.91)^2}$$

$$= \sqrt{3600 + 253.13}$$

$$= \sqrt{3853.13}$$

$$= 62.1\Omega$$

(iii) Current, I

$$I = \frac{V}{2} = \frac{200}{62.1} = 3.22$$

$$\therefore I = 3.22A$$

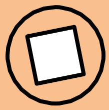
(iv) Power factor

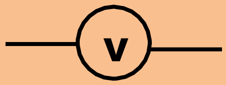
$$pf = \frac{R}{Z} = \frac{60}{62.1}$$

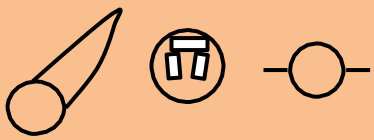
$$= 0.97 \text{ leading.}$$

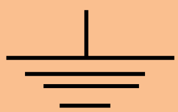
Question 6

Draw the following symbols to British Standards (BS):

(i)  Energy Meter

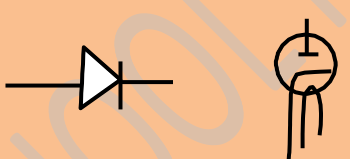
(ii)  Voltmeter

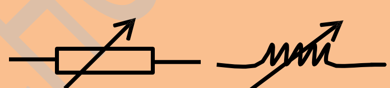
(iii)  Plug

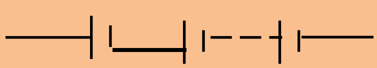
(iv)  Earth

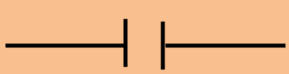
(v) Transformer or

(vi)  Variable Inductance

(vii)  Diode

(viii)  Variable Resistor

(ix)  Battery

(x)  Capacitor