JEE MAIN SEP 2020 (MEMORY BASED) | 4th Sep. SHIFT-2

Note: The answers are based on memory based questions which may be incomplete and incorrect.

1. Two disc made of same material and same thickness having radius R and α R. Their moment of inertia about their own axis are in ratio 1 : 16 respectively. Calculate the value of α

(1) 2 (2) $\frac{1}{2}$ (3) 1 (4) $\frac{1}{4}$

Ans. (1)

Sol. Moment of inertia of disc is given by $I = \frac{MR^2}{2} = \frac{[\rho(\pi R^2)]R^2}{2}$

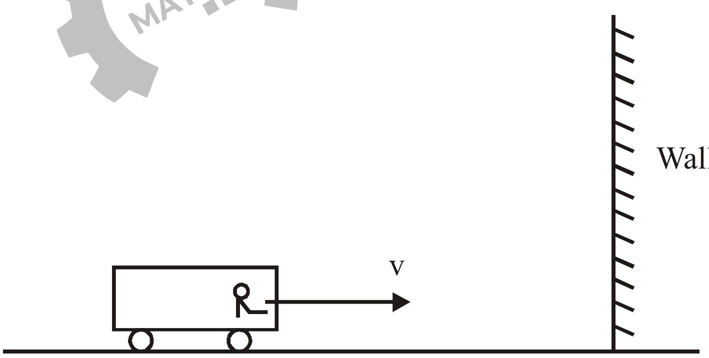
$$I \propto R^4$$

$$\frac{I_2}{I_1} = \left(\frac{R_2}{R_1}\right)^4 = \left(\frac{\alpha R}{R}\right)^4$$

$$\frac{16}{1} = \alpha^4$$

$$\alpha = 2$$

2. Bus moving with speed v towards a stationary wall. It produces sound of frequency f = 420 Hz, The heard frequency of reflected sound from wall by driver is 490 Hz. Calculate the speed 'v' of bus. The velocity of sound in air is 330 m/s



(1) 61 Km/hr (2) 71 Km/hr (3) 81 Km/hr (4) 91 Km/hr

Ans. (4)

Sol. Frequency appeared at wall

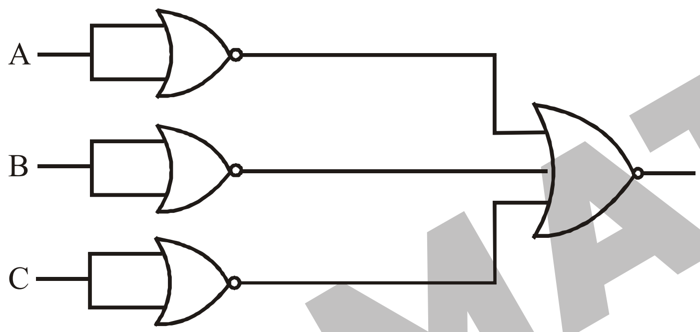
$$f_w = \frac{330}{330-v}.f \quad ...(1)$$

$$f' = \frac{330+v}{330}.f_w = \frac{330+v}{330-v}.f$$

$$490 = \frac{330+v}{330-v}.420$$

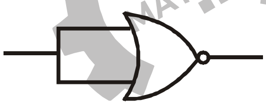
$$v = \frac{330\times 7}{91} \approx 25.38 m/s = 91 km/hr$$

3. The given circuit behaves like a following single gate



(1) OR (2) AND (3) NAND (4) NOR

Ans. (2)

Sol. 

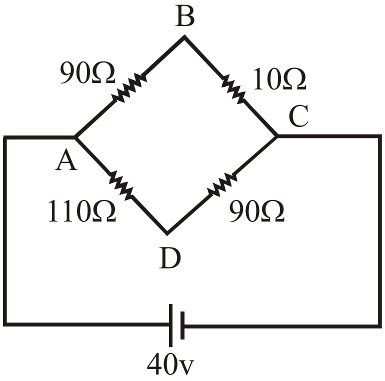
Behaves like a not gate so boolen equation will be

$$y = \overline{\overline{A}+\overline{B}+\overline{C}}$$

$$y = A.B.C$$

whole arrangement behaves like a AND gate

4.

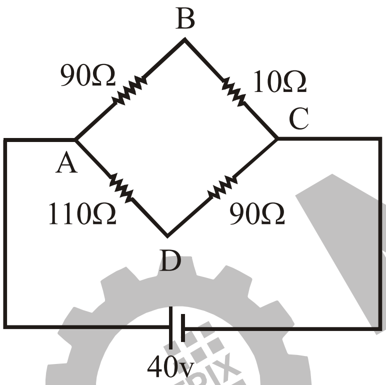


In the given circuit calculate the potential difference between points A and B

(1) 12 V (2) 24 V (3) 36 V (4) 48 V

Ans. (3)

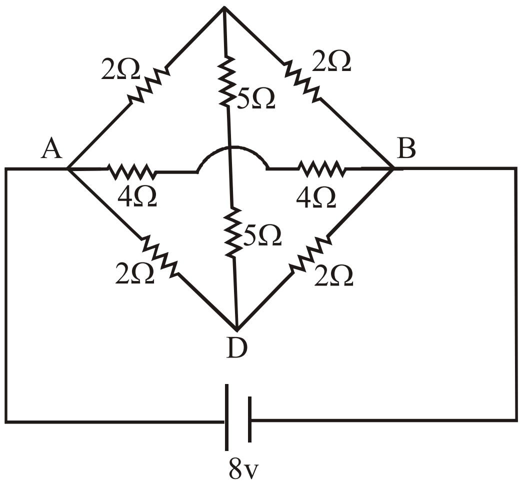
Sol.



Current in branch ABC = $I = \frac{40}{90+10} = 0.4A$

From ohm's law $V_{AB} = I \times R = 0.4 \times 90 = 36$ V

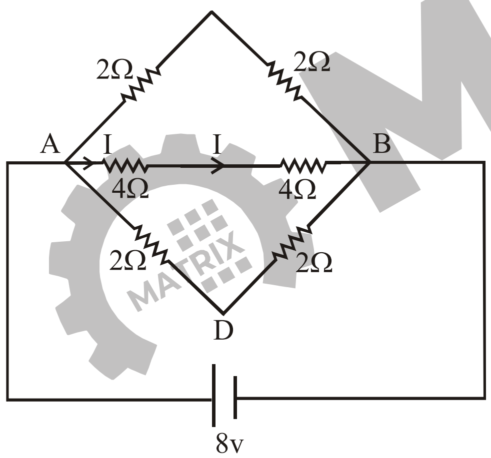
5. Find current through 4Ω resistance



(1) 1 Amp (2) 2 Amp (3) 3 Amp (4) 4 Amp

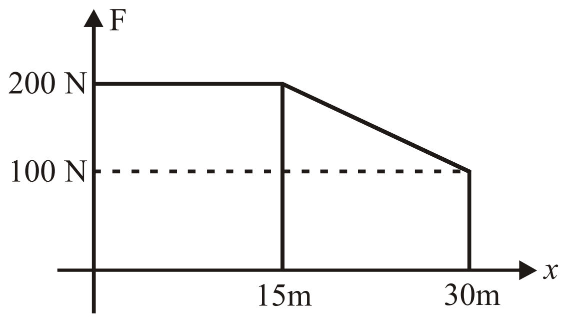
Ans. (1)

Sol.



$$I = \frac{8}{4+4} = 1\,\text{Amp}$$

6. Force on a particle varies with position (x) of particle as shown, calculate work done by force from x = 0 to x = 30 m



(1) 5250 J (2) 4250 J (3) 7500 J (4) 3750

Ans. (1)

Sol. $W = \text{area} = (200 \times 15) + \frac{1}{2}(100+200)\times 15$

$= 3000 + 2250$

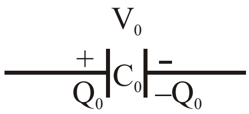
$W = 5250$ J

7. A capacitor of capacitance C_0 is charged to potential V_0. Now it is connected to another uncharged capacitor of capacitanc $\frac{C_0}{2}$. Calculate the heat loss in this process.

(1) $\frac{1}{2}C_0V_0^2$ (2) $\frac{1}{3}C_0V_0^2$ (3) $\frac{1}{6}C_0V_0^2$ (4) $\frac{1}{8}C_0V_0^2$

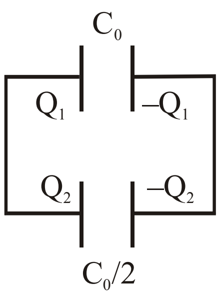
Ans. (3)

Sol.



Charge on capacitor before combined = $Q_0 = C_0V_0$

Now, combined this capacitor with another capacitor of capacitance $C_0/2$



Total charge remain constant so $Q_1 + Q_2 = Q_0$ .....(i)

also $\frac{Q_1}{C_0} = \frac{Q_2}{C_0/2} \Rightarrow Q_1 = 2Q_2$ .....(ii)

By solving equation (i) and (ii)

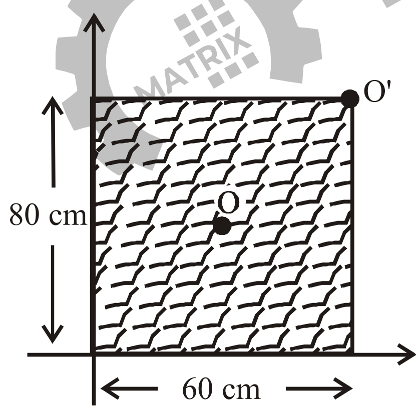
$Q_1 = \frac{2Q_0}{3}$, $Q_2 = \frac{Q_0}{3}$

$$\text{Loss} = U_i - U_f = \frac{Q_0^2}{2C_0} - \left[\frac{Q_1^2}{2C_0} + \frac{Q_2^2}{2\left(\frac{C_0}{2}\right)}\right]$$

$$= \frac{Q_0^2}{2C_0} - \left[\frac{\left(2\frac{Q_0}{3}\right)^2}{2C_0} + \frac{\left(\frac{Q_0}{3}\right)^2}{2\left(\frac{C_0}{2}\right)}\right]$$

$$= \frac{Q_0^2}{6C_0} = \frac{(C_0V_0)^2}{6C_0} = \frac{1}{6}C_0V_0^2$$

8. Find the Ratio of moment of inertia about axis perpendicular to rectangular plate passing through O & O'



(1) $\frac{1}{2}$ (2) $\frac{1}{3}$ (3) $\frac{1}{4}$ (4) $\frac{1}{8}$

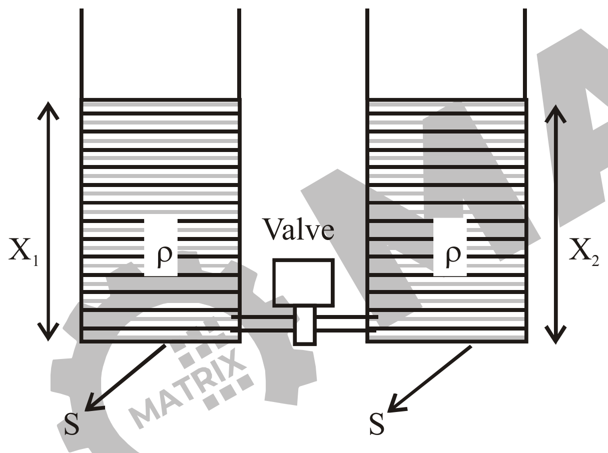
Ans. (3)

Sol. $\dfrac{I_O}{I_{O'}} = \dfrac{\frac{M}{12}(a^2+b^2)}{\frac{M}{12}(a^2+b^2)+M\left(\left(\frac{a}{2}\right)^2+\left(\frac{b}{2}\right)^2\right)}$

$$\frac{\frac{M}{12}(a^2+b^2)}{\frac{M}{3}(a^2+b^2)} = \frac{1}{4}$$

$$\frac{I_O}{I_{O'}} = \frac{1}{4}$$

9. Find the loss in gravitational potential energy of cylinder when valve is opened and level of liquid in both cylinder become same



(1) $\dfrac{\rho Ag(x_1-x_2)^2}{4}$ (2) $\dfrac{\rho Ag(x_1+x_2)^2}{4}$ (3) $\dfrac{\rho Ag(x_1^2-x_2^2)}{4}$ (4) $\dfrac{\rho Ag(x_1^2+x_2^2)}{4}$

Ans. (1)

Sol. Initial height of liquid in container's of same cross section are x_1 and x_2 respectively. Now valve is opened find loss in potential energy when water level become same

loss in PE = U_i - U_f

$$U = mgh = (\rho(A)(x))g\left(\frac{x}{2}\right)$$

x is level of liquid in container

where h is height of COM of liquid

New level is $x = \frac{x_1 + x_2}{2}$

and new height of COM = $h = \frac{x}{2} = \left(\frac{x_1 + x_2}{4}\right)$

$$U_i = \left[\rho(A)x_1\frac{x_1}{2} + \rho A x_2\frac{x_2}{2}\right]g$$

$$U_f = 2\times\left[\rho A\left(\frac{x_1 + x_2}{2}\right)\times\left(\frac{x_1 + x_2}{4}\right)\right]g$$

$$= \rho Ag\left[\frac{x_1^2}{2} + \frac{x_2^2}{2} - \frac{(x_1 + x_2)^2}{4}\right] = \frac{\rho Ag(x_1 - x_2)^2}{4}$$

10. A coil has moment of inertia 0.8 kg/m^2 released in uniform magnetic field 4T when there is 60° angle between magnetic field and magnetic moment of coil. Magnetic moment of coil is 20 A-m^2. Find the angular speed of coil when it passes through stable equilibrium.

(1) $20\pi\, rad/s^{-1}$ (2) $20\ rad/s^{-1}$ (3) $10\pi\, rad/s^{-1}$ (4) $10\ rad/s^{-1}$

Ans. (4)

Sol. From energy conservation

$$\frac{1}{2}I\omega^2 = U_{in} - U_f$$

$$= -MB\cos 60° - (-MB\ \cos(0°))$$

$$\frac{MB}{2} = \frac{1}{2}I\omega^2$$

$$\frac{20\times 4}{2} = \frac{1}{4}(0.8)\omega^2$$

$$100 = \omega^2$$

$$\omega = 10\, rad$$

11. A charged particle of charge q released in electric field $E = E_0(1-ax^2)$ from origin. Find position when its kinetic energy again becomes zero.

(1) $\sqrt{\frac{1}{a}}$ (2) $\sqrt{\frac{2}{a}}$ (3) $\sqrt{\frac{3}{a}}$ (4) $2\sqrt{\frac{1}{a}}$

Ans. (3)

Sol. $W_{ex} = \Delta K \qquad K_f - K_i = 0$

$$\int_0^x qEdx = 0$$

$$q\int_0^x E_0(1-ax^2)dx = 0$$

$$qE_0\int_0^x (1-ax^2)dx = 0$$

$$x - \frac{ax^3}{3} = 0$$

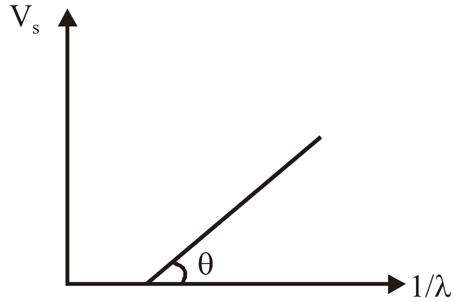
$$1 - \frac{ax^2}{3} = 0$$

$$\frac{ax^2}{3} = 1$$

$$x^2 = \frac{3}{a}$$

$$x = \pm\sqrt{\frac{3}{a}}$$

12. A light is incident on a metallic surface. Graph between stopping potential V_s and $1/\lambda$ is as shown in figure. When intensity of light is increase at given frequency then:



(1) Graph does not change

(2) Graph steeper

(3) V_s intercept change

(4) Graph gets narrower

Ans. (1)

Sol. $eV_s = h\nu - w$

$$V_s = \frac{h\nu}{e} - \frac{w}{e}$$

Frequency and work function are constant therefore graph doesn not change.

13. A ball is thrown with velocity v_0 from ground in vertical upward direction. If particle experiences resistance force ' mkv^2 '. Where v is the speed of particle, m mass of the particle and k is a positive constant. Find maximum height reached.

(1) $\frac{1}{2K}ln\left(\frac{g+kv_0^2}{g}\right)$ (2) $\frac{1}{3K}ln\left(\frac{g+kv_0^2}{g}\right)$ (3) $\frac{2}{3K}ln\left(\frac{g+kv_0^2}{g}\right)$ (4) $\frac{1}{K}ln\left(\frac{g+kv_0^2}{g}\right)$

Ans. (1)

Sol. $F_{net} = ma$

$$-mg - mkv^2 = mv\frac{dv}{ds}$$

$$v\frac{dv}{ds} = -g - kv^2$$

$$-\int_{v_0}^{0}\frac{vdv}{g+kv^2} = \int_0^{h_{max}} ds = h_{max}$$

$$h_{max} = \frac{1}{2k}ln\left(\frac{g+kv_0^2}{g}\right)$$

14. Light of wavelength 6000×10^{-10} m passes through a single slit of width 0.6×10^{-4} m. Find height of highest order of minima on both side central maxima

(1) 10 (2) 20 (3) 100 (4) 200

Ans. (3)

Sol. Light of wavelength 6000×10^{-10} m passes through a single slit of width 0.6×10^{-4} m. Find height of highest order of minima on both side central maxima

for minima

$d\sin\theta = n\lambda$

$\sin\theta = \frac{n\lambda}{d} < 1$

$n \le \frac{d}{\lambda}$

$n < \frac{0.6 \times 10^{-4}}{6000 \times 10^{-10}}$

$n < 100$

15. Maximum wavelength of Lyman series photon for H is λ. Then minimum wavelength of Balmer series photon for He^+ atom

(1) λ/4 (2) 3λ/4 (3) λ/4 (4) 2λ/3

Ans. (2)

Sol. For maximum wavelength of Lyman $(2 \to 1)$

$\frac{1}{\lambda_H} = R\left(1 - \frac{1}{4}\right)$

$\frac{1}{\lambda} = \frac{3R}{4}$ ......(i)

For minimum wavelength of Balmer $(\infty \to 2)$

$\frac{1}{\lambda_{He^+}} = R(4)\left(\frac{1}{4} - \frac{1}{\infty}\right) = R$

$$\frac{1}{\lambda_{He^+}} = R \qquad \text{......(ii)}$$

By solving (i) and (ii)

$$\lambda_{He^+} = \frac{3\lambda}{4}$$

16. Electric field in EM waves is $E = E_0\left(\hat{i}+\hat{j}\right)\sin(kz-\omega t)$, then equation of magnetic field is :

(1) $B = B_0\left(-\hat{i}+\hat{j}\right).\sin(kz-\omega t)$

(2) $B = B_C\left(\hat{i}+\hat{j}\right).\sin(kz-\omega t)$

(3) $B = B_C\left(\hat{j}+\hat{k}\right).\sin(kz-\omega t)$

(4) $B = B_0\left(\hat{i}+\hat{j}\right).\sin(kz-\omega t)$

Ans. (1)

Sol. $\frac{E_0}{B_0} = C \quad \Rightarrow B_0 = \frac{E_0}{C}$

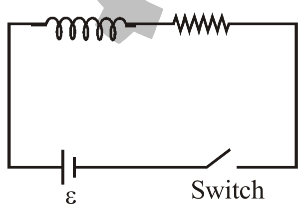
Wave is propagating in +z direction

$\vec{E}\times\vec{B}$ must be in +z direction

hence, $\vec{B}$ must be parallel to vector $(-\hat{i}+\hat{j})$

$$\vec{B} = \frac{E_0}{C}\sin(kz-\omega t)\left(-\hat{i}+\hat{j}\right)$$

17. The circuit is switched on at t = 0, Find the time when energy stored in inductor becomes 1/n times of maximum energy stored in it :



(1) $\frac{L}{R}\ln\frac{\sqrt{n}}{\sqrt{n}+1}$ (2) $\frac{L}{R}\ln\frac{\sqrt{n}}{\sqrt{n}-1}$ (3) $\frac{L}{R}\ln\frac{\sqrt{n}+1}{\sqrt{n}}$ (4) $\frac{L}{R}\ln\frac{\sqrt{n}-1}{\sqrt{n}}$

Ans. (2)

Sol. Energy stored in inductor is given by $U = \frac{1}{2}LI^2$

$U \propto I^2$

$\frac{U}{U_0} = \left(\frac{I}{I_0}\right)^2$, where U_0 is maximum energy stored

$\frac{1}{n} = \left(\frac{I}{I_0}\right)^2 \Rightarrow \frac{I}{I_0} = \frac{1}{\sqrt{n}}$

Current at time 't' through inductor

$I = I_0 (1 - e^{-t/\tau})$

$\frac{I}{I_0} = 1 - e^{-Rt/L} = \frac{1}{\sqrt{n}}$

$t = \frac{L}{R} \ln \frac{\sqrt{n}}{\sqrt{n} - 1}$

18. Intensity of magnetization is 4 (unit) at temperature 6 K and B = 0.4 T. What is the intensity of magnetization at temperature 24 K in B = 0.3 T

(1) 0.75 (2) 0.25 (3) 0.5 (4) 1

Ans. (1)

Sol. Magnetization = 4 given $\Rightarrow$ at, T = 6k, B = 0.4 T $\Rightarrow$ Magnetization(M) = 4

at, T = 24k, B = 0.3 T, M = ?

as we know magnetisation $M = \frac{CB_{ext}}{T}$

$M \propto \frac{B_{ext}}{T}$

$\frac{M}{4} = \left(\frac{0.3}{24}\right) \div \left(\frac{0.4}{6}\right)$

$\Rightarrow M = 0.75$

19. Match the following

I Adiabatic	(A) $\Delta U = 0$
II Isothermal	(B) $\Delta W = 0$
III Isobaric	(C) $\Delta Q = 0$
IV Isochoric	(D) $\Delta U \neq 0$
	$\Delta Q \neq 0$
	$\Delta W \neq 0$

(1) I - A, II - C, III - D, IV - B
(2) I - D, II - B, III - C, IV - A
(3) I -C, II - A, III - D, IV - B
(4) I - B, II - D, III - C, IV - A

Ans. (3)

Sol. Part of theory

20. A Satellite is revolving around the earth. Ratio of its orbital speed and escape speed will be :

(1) $\frac{1}{\sqrt{2}}$
(2) $\sqrt{2}$
(3) $\sqrt{3}$
(4) $\frac{2}{\sqrt{2}}$

Ans. (1)

Sol. Orbital speed $V_0 = \sqrt{\frac{GM}{r}}$

escape speed $V_e = \sqrt{\frac{2GM}{r}}$

$$\frac{v_0}{v_e} = \frac{\sqrt{\frac{Gm}{r}}}{\sqrt{\frac{2Gm}{r}}} = \frac{1}{\sqrt{2}}$$

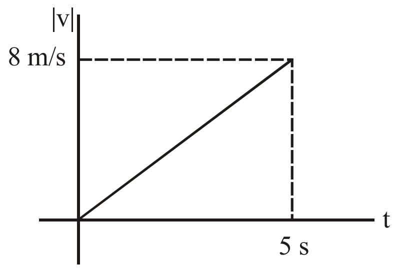
21. If I is moment of inertia, F is force, v is velocity, E is energy and L is length then, dimension of $\frac{I\,F\,v^2}{E\;L^4}$ will be :

(1) Energy density (2) Viscosity (3) Young modulus (4) Torque

Ans. (1)

Sol. $\frac{I\,F\,v^2}{E\;L^4} = \frac{(M^1L^2)(M^1L^1T^{-2})(L^1T^{-1})^2}{(M^1L^2T^{-2})(L^4)} = M^1L^{-1}T^{-2} = \text{Energy density}$

22. Speed time graph of a particle is shown in figure. Find distance travelled by particle in 5 second.



Ans. 20.00

Sol. Distance = Area of |v| – t graph

= 1/2 × 8 × 5 = 20 m

23. In displacement method, distance between lens and screen is 100 cm Initial image is obtained on screen. Now lens is displaced 40 cm image formed on screen again. If power of the lens is (100/N) dioptre, then find the value of N :

Ans. 21.00

Sol. Focal length of lens = $f = \frac{D^2 - d^2}{4D} = \frac{100^2 - 40^2}{4(100)} = \frac{(100+40)(100-40)}{4(100)}$

$= \frac{140 \times 60}{4 \times 100} = \frac{14 \times 6}{4} = 21\text{cm}$

$\text{Power} = \frac{100}{f\,(\text{in cm})} = \frac{100}{21} = \frac{100}{21}\text{D}$

24. Binding energy per nucleon of $_{50}Sn^{120}$ approximately will be. [Atomic mass of Sn^{120} is 120.500 u and that of ^{1}H is 1.007 u. Mass of neutron = 1.008 u, $1uc^2 = 931$ MeV/u]

Ans. 3.18 MeV

Sol. The binding energy of $_{50}Sn^{120}$ is

$E = [50 \times 1.007\ u + 70 \times 1.008\ u - 120.500\ u]\ c^2 = (0.41\ u)c^2$

$E = (0.41\ u)\ (931\ MeV/u) = 381.71\ MeV.$

number of nucleons in $_{50}Sn^{120} \Rightarrow n = 120$

Binding energy per nucleon $= \frac{E}{n} = \frac{381.71}{120} = 3.18 MeV$