30 A detector placed close to a radioactive source measures an activity of 320 Bq. The background activity at this location is 20 Bq. The radioactive nuclide has a half-life of 12 hours.

What activity is measured after 9 hours?

A 178 Bq **B** 198 Bq **C** 225 Bq **D** 245 Bq

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Tampines Meridian Junior College
2024 JC2 H2 Physics Preliminary Examination Paper 1
Suggested Solution

1	**C**	**11**	**C**	**21**	**A**
2	**C**	**12**	**B**	**22**	**C**
3	**A**	**13**	**B**	**23**	**A**
4	**B**	**14**	**B**	**24**	**D**
5	**A**	**15**	**D**	**25**	**D**
6	**C**	**16**	**A**	**26**	**C**
7	**D**	**17**	**A**	**27**	**D**
8	**D**	**18**	**B**	**28**	**C**
9	**B**	**19**	**C**	**29**	**D**
10	**B**	**20**	**A**	**30**	**B**

Q1 Ans: C

Estimated length = 14.0 cm

Estimated diameter = 1.0 cm

Assuming the cross sectional area is a circle, volume $= \pi \left(\frac{1.0}{2}\right)^2 14.0$

$= 11 \text{ cm}^3$

Q2 Ans: C

Explanation

change in velocity = total area under graph

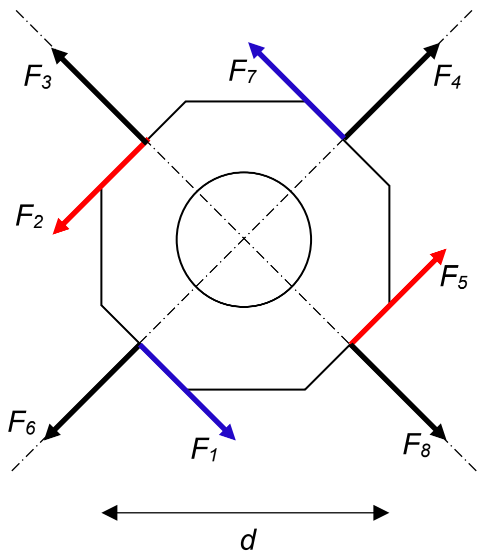
total area under graph = ½ × 4.0 × 2.4 + (−½ × 6.0 × 3.6) = −6.0 m s^{-1}

Q3 Ans: A

Newton's 2nd Law: The forces need to act on the same body (to produce a resultant force).
Hence, only the pair F_3 and F_4 satisfy this condition.

Newton's 3rd Law: The forces need to act on different bodies.
Hence, only the pair F_2 and F_4 satisfy this condition.

Q4 Ans: B



Torque of a couple = Fd (one set (blue arrows); another set (red arrows))

Hence, total torque = Fd + Fd = 2Fd

*The other forces pass through the cg; hence no torque is generated.

Q5 Ans: A

The effect of atmospheric pressure cancels out at the top and bottom of the drum.

At equilibrium,

$$\begin{aligned}\text{weight of drum \& content} &= \text{weight of water displaced} \\ &= V\rho g \\ &= 0.80 \times 0.19 \times 1.1 \times 10^3 \times 9.81 \\ &= 1640 \text{ N}\end{aligned}$$

$$\text{mass of drum \& content} = \frac{1640}{9.81} = 167 \text{ kg}$$

Q6 Ans: C

Output power of the motor = (100 - 20)(0.30)(50) = 1200 W

Electrical power supplied to the motor = $\frac{1200}{0.2} = 6000\text{ W}$

Q7 Ans: D

Explanation

angular velocity = $\frac{v}{r}=\frac{6.0}{0.40}=15$ rad s^{-1}

angular displacement = angle $=\frac{\pi}{2}=1.6$ rad

Q8 Ans: D

Explanation

gravitational force $F=\frac{GMm}{r^2}$

on the ground, F = W and r = R: $W=\frac{GMm}{R^2}$ …… equation 1

at a height 2R above the ground, r = 3R: $F=\frac{GMm}{(3R)^2}$ …… equation 2

equation 2 divide by equation 1 gives $F=\frac{W}{9}$

Q9 Ans: B

Explanation

for orbiting satellite:

gravitational force provides centripetal force

$$\frac{GMm}{r^2}=mr\left(\frac{2\pi}{T}\right)^2$$

$$T^2=\frac{4\pi^2}{GM}r^3$$

the radius r of orbit is independent of the mass m of the satellite

so the radius is the same

Q10 Ans: B

Explanation

amplitude x_0 = 4.0 m

max speed $v_0 = \omega x_0$

$20 = \omega \times 4.0$

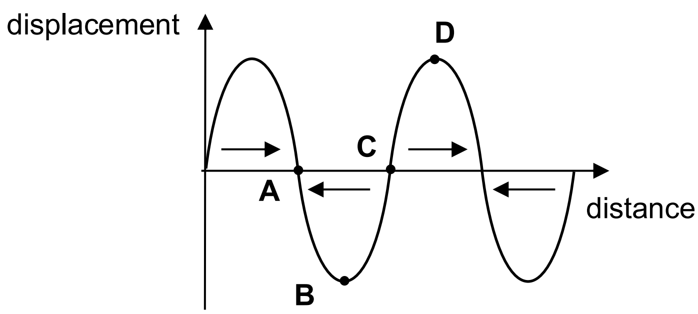
so $\omega = 5.0$

period T = $\frac{2\pi}{\omega} = \frac{2\pi}{5.0} = 1.257$ s

time for speed to reduce from max to zero = $\frac{1}{4}T = \frac{1}{4} \times 1.257 = 0.31$ s

Q11 Ans: C

Since displacement towards the right is taken as positive, we can label the directions of displacement of air molecules as follows:



It can be seen from the figure that at point **C**, it is a region of rarefaction as air molecules on the left side of **C** is displaced to the left and on the right side of **A**, they are displaced to the right. Hence **C** has the minimum pressure.

Q12 Ans: B

$I \propto A^2$

$$\frac{I_1}{I_2} = \frac{A_1^2}{A_2^2} \Rightarrow \sqrt{\frac{0.36}{0.25}} = \frac{A_1}{A_2} \Rightarrow A_1 = 1.2A_2$$

At P (minima), the resultant amplitude, $A_p = 1.2A_2 - A_2 = 0.2\,A_2$

$$\frac{I_P}{I_2} = \frac{{A_P}^2}{{A_2}^2} \Rightarrow \frac{I_P}{0.25I} = \frac{0.2{A_2}^2}{{A_2}^2} = 0.040 \Rightarrow I_P = 0.010I$$

Or $A_p = 0.6A - 0.5A = 0.1A$

$\Rightarrow I_P = 0.010I$

Q13 Ans: B

Points in alternate segments of a standing wave are in anti-phase (have a phase difference of π).

Q14 Ans: B

Since the container is sealed, volume remains constant. Hence, average distance between the gas molecules does not change.

Q15 Ans: D

From First Law of Thermodynamics, $\Delta U = Q + W$

When Q is zero, internal energy of the system can still increase if there is work done on the system (W is positive).

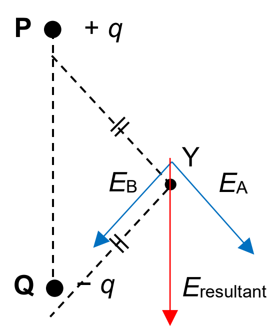
Q16 Ans: A

$$P_{cooling} = P_{freezing}$$

$$\frac{mc\Delta\theta}{t} = \frac{ml_f}{t_f}$$

$$\frac{c}{l_f} = \frac{1}{1.5 \times 30} = \frac{1}{45}$$

Q17 Ans: A



Q18 Ans: B

Note that the middle resistor is redundant as the pd across it is the same, hence no current flow.

Hence $R_E = \left(\frac{1}{R+R} + \frac{1}{R+R}\right)^{-1} = R$

Q19 Ans: C

$R_{\text{eff across PQ}}$ = $\left(\frac{1}{20} + \frac{1}{8+3}\right)^{-1}$ = 7.10 Ω

V_{PQ} = $\frac{R_{PQ}}{R_{PQ} + R_{10\Omega}} \times 6.0 = \frac{7.10}{7.10 + 10} \times 6.0 = 2.5$ V

Q20 Ans: A

With bulb 3 in parallel to bulb 2, the potential difference across bulb 2 is a smaller fraction of the cell's e.m.f as compared to that of bulbs 1 and 4.
With bulb 3 removed, the potential difference across bulb 2 increases while those of bulb 1 and bulb 4 decrease correspondingly. With fixed resistance, power dissipated increases as potential increases, hence bulbs 1 and 4 became dimmer and bulb 2 became brighter.

Q21 Ans: A

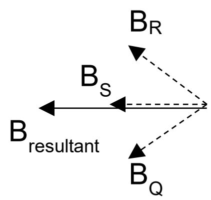
$F_{AB} = (0.50)(1.0)(0.20)\sin(30°) = 0.050$ N into the paper

$F_{BC} = (0.50)(1.0)(0.20)\sin(0°) = 0$ N

$F_{CD} = (0.50)(1.0)(0.20)\sin(90°) = 0.10$ N out of the paper

Net force $= 0.10 - 0.050 = 0.050$ N out of the paper

Q22 Ans: C



Q23 Ans: A

The change of magnetic flux linkage is a constant. Hence, induced emf is zero resulting in zero induced current.

Q24 Ans: D

Electrons either accumulate in the centre or at the rim. In either case, 2 points equidistant from O will have the same potential, and the difference in potential between O and a point gets larger with distance. Therefore, $E_{XY} = E_{YZ}$.
Since points further from O travel faster, the length XY cuts flux faster than YO. Therefore, $E_{XY} > E_{YO}$.

Q25 Ans: D

Using $I_{rms} = \dfrac{P}{V}$

I_{rms} ranges from 9.55 A to 10.4 A

I_o ranges from 13.5 A to 14.7 A

Hence most probable expression for the current is I = 14.1 sin (375t)

Q26 Ans: C

$$P' = 4P$$

$$= 4\left(\frac{I_o}{\sqrt{2}}\right)^2 R$$

$$\left(I_{rms}'\right)^2 R = 4\left(\frac{I_o}{\sqrt{2}}\right)^2 R$$

$$\left(I_{rms}'\right)^2 = 2I_o^2$$

$$I_{rms}' = \sqrt{2}I_o$$

Q27 Ans: D

$$E_{k\max} = \frac{(p_{\max})^2}{2m}$$

$$\begin{aligned}\lambda_{\min} &= \frac{h}{p_{\max}} \\ &= \frac{h}{\sqrt{2mE_{k\max}}} \\ &= \frac{6.63\times10^{-34}}{\sqrt{2\times9.11\times10^{-31}\times9.0\times10^{-20}}} \\ &= 1.6\times10^{-9}\ \text{m}\end{aligned}$$

Q28 Ans: C

$$\begin{aligned}p &= mv_x \\ \Delta p &= m\Delta v_x \\ &= 9.11\times10^{-31}\times\frac{0.50}{100}\times0.6\times3.00\times10^{8} \\ &= 8.199\times10^{-25}\ \text{kg m s}^{-1}\end{aligned}$$

$$\Delta x\cdot\Delta p = h$$

$$\Delta x = \frac{6.63\times10^{-34}}{8.199\times10^{-25}} = 8.09\times10^{-10}\ \text{m}$$

Q29 Ans: D

Activity A is the number of decays per unit time.

The shaded area S is therefore the total number of decays in time T.

The value $\frac{E}{S}$ is the total energy of the decays in time T divided by the total number of decays, hence it is the energy released per radioactive decay.

Q30 Ans: B

The corrected count rate initially is

320 – 20 = 300 Bq

The corrected count rate after 9 hours is

$$CCR = 300(\frac{1}{2})^{\frac{9}{12}} = 178 \text{ Bq}$$

The observed count rate after 9 hours is

C = 178 + 20 = 198 Bq