Physics Standard level Paper 1 Wednesday 28 October 2020 (afternoon)

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IB PHYSICS SL PAPER-1 28 OCT-2020 SOLUTION WITH EXPLANATION

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1. Which quantity has the same units as those for energy stored per unit volume?

A. Density
B. Force
C. Momentum
D. Pressure

Energy stored per unit volume $= \frac{\text{Energy}}{\text{Volume}} = \frac{ML^2T^{-2}}{L^3} = ML^{-1}T^{-2}$

$\text{DENSITY} = \frac{\text{Mass}}{\text{Volume}} = \frac{M}{L^3} = ML^{-3}$

Force = mass × acceleration $= kg.\ mt/sec^2 = MLT^{-2}$

Momentum $p = mv = kg\ \frac{mt}{sec} = MLT^{-1}$

Pressure $= \frac{\text{force}}{\text{Area}} = \frac{MLT^{-2}}{L^2} = ML^{-1}T^{-2}$

Same as energy stored per unit volume

2) A list of four physical quantities is

- acceleration
- energy
- mass
- temperature

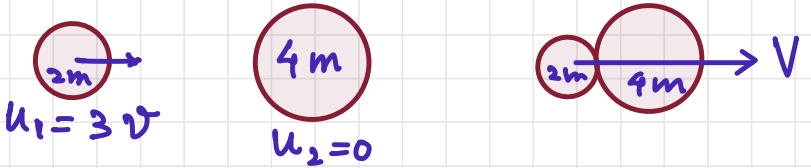
How many scalar quantities are in this list?

A. 1
B. 2
C. 3
D. 4

Acceleration – Vector
Energy – Scalar
Mass – Scalar
Temp – Scalar

3) An object of mass 2m moving at velocity 3v collides with a stationary object of mass 4m. The objects stick together after the collision. What is the final speed and the change in total kinetic energy immediately after the collision?

	Final speed	Change in total kinetic energy
A.	v	$3mv^2$
B. ✓	v	$6mv^2$
C.	$2v$	$3mv^2$
D.	$2v$	$6mv^2$



Applying conservation of linear momentum

$$2m(3v) + 4m(0) = (6m)V$$

$$V = \frac{(2m)(3v)}{6m} = v$$

change in KE = $(KE)_{final} - (KE)_{initial}$

$$= \frac{1}{2}(6m)v^2 - \frac{1}{2}(2m)(3v)^2$$

$$= 3mv^2 - m(9v^2)$$

$$= -6mv^2$$

4. An object of mass 1 kg is thrown downwards from a height of 20 m. The initial speed of the object is 6ms-1. The object hits the ground at a speed of 20 m s-1. Assume g = 10 m s-2. What is the best estimate of the energy transferred from the object to the air as it falls?

A. 6J

B. 18J

C. 182 J

D. 200 J

$K_f - K_i$ = Total work done

$\frac{1}{2}m(20)^2 - \frac{1}{2}m(6)^2 = (mg)(20) - f(1)$

$f(1) = g(20) - \frac{(20)^2}{2} + \frac{(6)^2}{2}$

$= 200 - \frac{400}{2} + \frac{36}{2}$

$= 200 - 200 + 18$

$= 18J$

5. An object of mass 8.0 kg is falling vertically through the air. The drag force acting on the object is 60 N. What is the best estimate of the acceleration of the object?

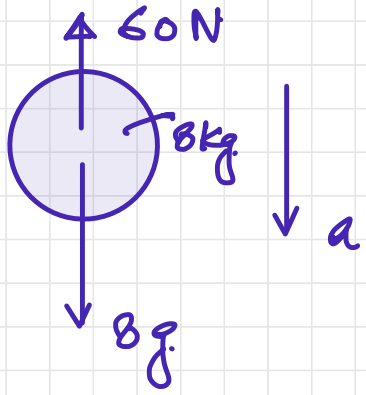
A. Zero
B. 2.5 m s-2
C. 7.5 m s-2
D. 10ms-2

$$8g - 60 = 8(a)$$

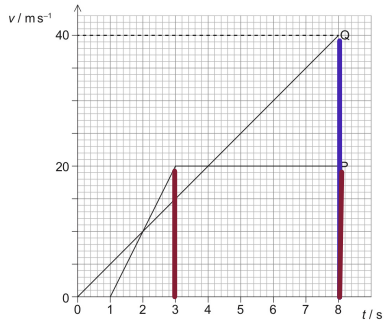
$$80 - 60 = 8(a)$$

$$a = \frac{20 \text{ to } 5}{8 \text{ kg}}$$

$$= 2.5\ m\ s^{-2}$$



6. P and Q leave the same point, travelling in the same direction. The graphs show the variation with time t of velocity v for both P and Q.



What is the distance between P and Q when t = 8.0 s?

A. 20m
B. 40m
C. 60m
D. 120m

$A_1 = \frac{1}{2} \times 8 \times 40 = 160$ mt

$A_2 = \frac{1}{2} \times 20 \times 2 + 20 \times 5$

$= 20 + 100 = 120$

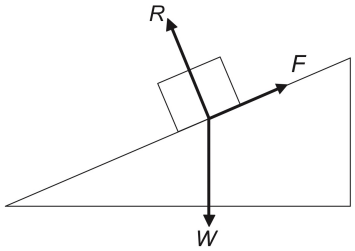
Distance between P & Q.

$= 160 - 120$

$= 40$ mt

Area of velocity time graph gives distance travelled / displacement

7). Three forces act on a block which is sliding down a slope at constant speed. W is the weight, R is the reaction force at the surface of the block and F is the friction force acting on the block.



In this situation
A. there must be an unbalanced force down the plane.
B. W=R.
C. F=W.
D. the resultant force on the block is zero.

→ Constant speed

A = Acceleration = $\frac{dV}{dt} = 0$

Since V = constant

Hence the resultant force on the block is ZERO

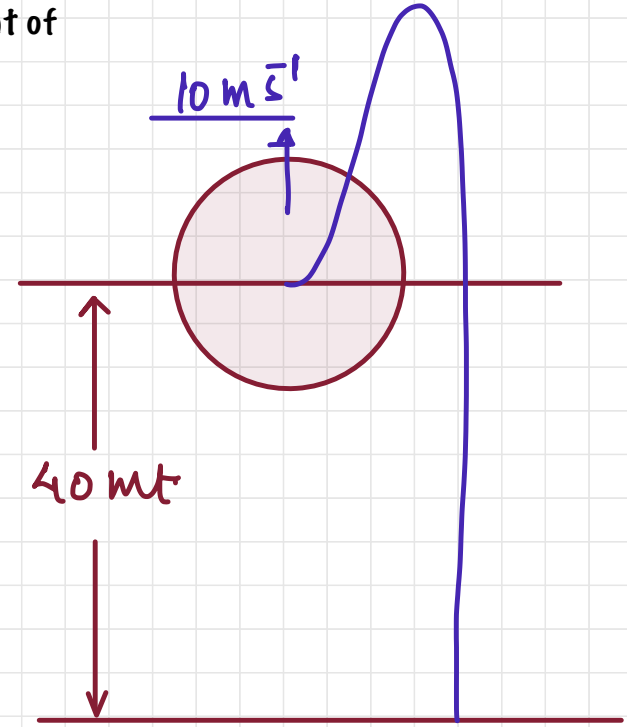
8. A balloon rises at a steady vertical velocity of 10 m s-1. An object is dropped from the balloon at a height of 40 m above the ground. Air resistance is negligible. What is the time taken for the object to hit the ground?

A. 10s

B. 5s

C. 4s

D. 2s



$s_y = u_y t + \frac{1}{2} a_y t^2$

$-40 = 10(t) - \frac{1}{2} \times 10 \times t^2$

$5t^2 - 10(t) - 40 = 0$

$t^2 - 2t - 8 = 0$

$t^2 - 4t + 2t - 8 = 0$

$t(t-4) + 2(t-4) = 0$

$(t-4)(t+2) = 0$

$t = 4$ sec

9) An object of mass m strikes a vertical wall horizontally at speed U. The object rebounds from the wall horizontally at speed V.
What is the magnitude of the change in the momentum of the object?

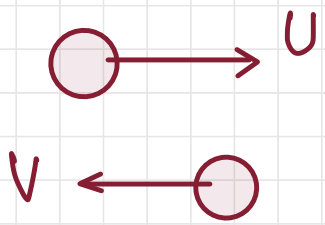
A. 0
B. m(V-U)
C. m(U-V)
D. m(U+V)

change in momentum

$= m(V_f - V_i)$

$= m(V - (-U))$

$= m(V+U)$



magnitude of change in momentum

$= |m(V+U)|$

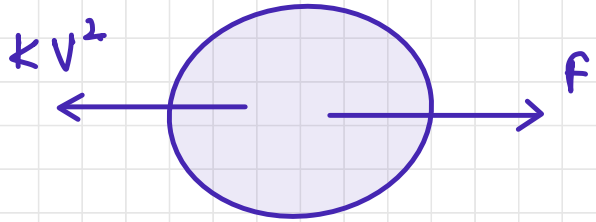
10. A horizontal force F acts on a sphere. A horizontal resistive force kv^2 acts on the sphere where v is the speed of the sphere and k is a constant. What is the terminal velocity of the sphere?

A. $\sqrt{\frac{k}{F}}$

B. $\frac{k}{F}$

C. $\frac{F}{k}$

D. $\sqrt{\frac{F}{k}}$



$F - kV^2 = 0$

$v = \sqrt{F/k}$

11. An ideal gas of constant mass is heated in a container of constant volume. What is the reason for the increase in pressure of the gas?

A. The average number of molecules per unit volume increases.

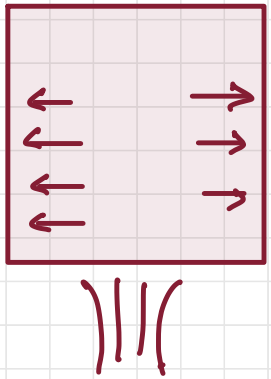
B. The average force per impact at the container wall increases.

C. Molecules collide with each other more frequently.

D. Molecules occupy a greater fractional volume of the container.

KE of gas molecule increases as increasing the temperature

$T \uparrow \quad KE \uparrow \quad F \uparrow$



12. A substance in the gas state has a density about 1000 times less than when it is in the liquid state. The diameter of a molecule is d. What is the best estimate of the average distance between molecules in the gas state?

A. d

B. 10d

C. 100d

D. 1000d

$V = d \times d \times d \leftarrow 1000$

$10 \times 10 \times 10$

↳ can be written as $10 \times 10 \times 1d$

therefore Avg distance between molecules in the gas state $= 10d$

13. A bicycle of mass M comes to rest from speed v using the back brake. The brake has a specific heat capacity of c and a mass m. Half of the kinetic energy is absorbed by the brake. What is the change in temperature of the brake?

A. $\frac{Mv^2}{4mc}$

B. $\frac{Mv^2}{2mc}$

C. $\frac{mv^2}{4Mc}$

D. $\frac{mv^2}{2Mc}$

$$\frac{1}{2}\left(\frac{1}{2}MV^2\right) = M.c.\Delta T$$

$$\Delta T = \frac{MV^2}{4mc}$$

14. An object moves with simple harmonic motion. The acceleration of the object is
A. constant.
B. always directed away from the centre of the oscillation.
C. a maximum at the centre of the oscillation.
D. a maximum at the extremes of the oscillation.

$A = -\omega^2 a \sin \omega t$

for maximum acceleratm.

$A = -\omega^2 g \qquad g = a$

$A = -\omega^2 a$

$|A| = |-\omega^2 a| = \omega^2 a$

15. A travelling wave has a frequency of 500 Hz. The closest distance between two points on the wave that have a phase difference of $60°\left(\frac{\pi}{3}\text{rad}\right)$ is 0.050 m . What is the speed of the wave?

A. 25ms-1

B. 75ms-1

C. 150 m s-1

D. 300 m s-1

$$\Delta\phi = \frac{2\pi}{\lambda}(\Delta x)$$

$$(\text{phase difference}) = \frac{2\pi}{\lambda}(\text{path difference})$$

$$\frac{\pi}{3} = \frac{2\pi}{\lambda}(\cdot 050)$$

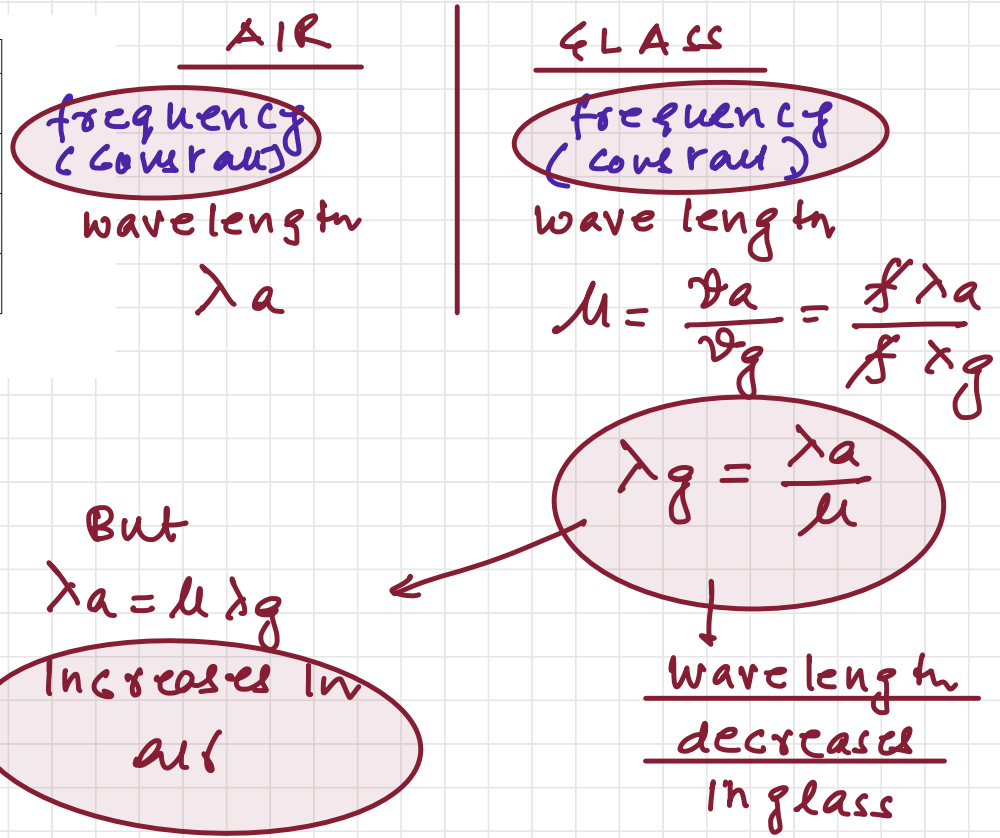
$$\lambda = (3)(2)(\cdot 050)\ m$$

$$v = f\lambda$$

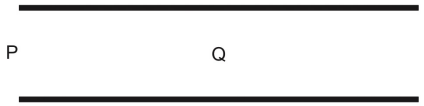
$$v = \frac{500 \times 3 \times 2 \times 050}{1000 \cancel{2}} = 150\ m\,s^{-1}$$

16. What changes occur to the frequency and wavelength of monochromatic light when it travels from glass to air?

	Frequency	Wavelength
A.	stays the same	stays the same
B. ✓	stays the same	increases
C.	increases	stays the same
D.	decreases	increases



17. The air in a pipe, open at both ends, vibrates in the second harmonic mode.



What is the phase difference between the motion of a particle at P and the motion of a particle at Q?

A. 0

B. $\frac{\pi}{2}$

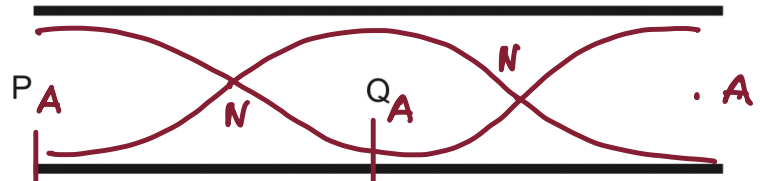
C. π ✓

D. 2π

$\Delta\phi = \frac{2\pi}{\lambda}(\Delta x)$

$\Delta x = \lambda/2$

$\Delta\phi = \frac{2\pi}{\lambda}\left(\frac{\lambda}{2}\right) = \pi$



second harmonic of open organ pipe

18. A metal wire has n free charge carriers per unit volume. The charge on the carrier is q. What additional quantity is needed to determine the current per unit area in the wire?

A. Cross-sectional area of the wire

B. Drift speed of charge carriers

C. Potential difference across the wire

D. Resistivity of the metal

$I = n e A v_d$

n → electron density

v_d → drift velocity.

$\frac{I}{A} = n e v_d$

$= n q v_d$

v_d → need drift velocity

19. An electric motor raises an object of weight 500 N through a vertical distance of 3.0 m in 1.5 s. The current in the electric motor is 10 A at a potential difference of 200 V. What is the efficiency of the electric motor?

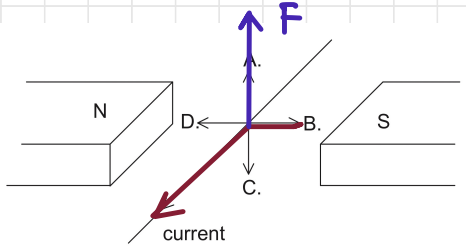
A. 17%
B. 38%
C. 50%
D. 75%

$$\eta_{\text{electric motor}} = \frac{\text{output power (f.d)}}{\text{Input power (VIt)}} \times 100\%$$

$$= \frac{(500 \times 3.0)^{1}}{(200)(10)(1.5)} \times 100\ \%$$

$$= \frac{500}{10} = 50\%$$

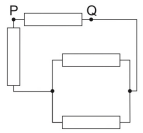
20. A current in a wire lies between the poles of a magnet. What is the direction of the electromagnetic force on the wire?



Bf fleming left hand rule

Direction is upward

21. Four resistors of 4 Ω each are connected as shown.



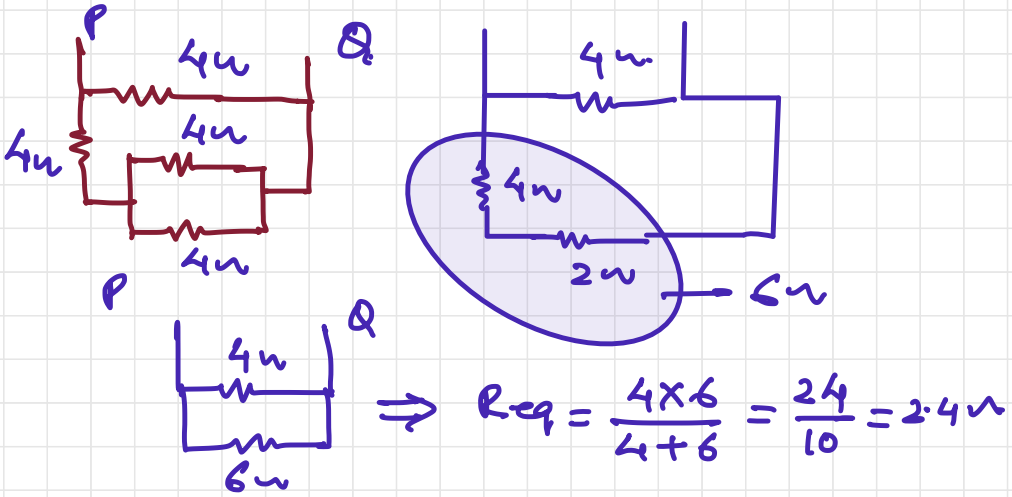
What is the effective resistance between P and Q?

A. 1.0Ω

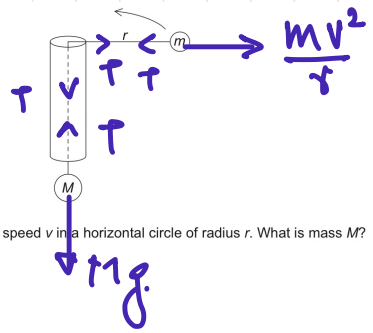
✓ B. 2.4Ω

C. 3.4Ω

D. 4.0Ω



22. Mass M is attached to one end of a string. The string is passed through a hollow tube and mass m is attached to the other end. Friction between the tube and string is negligible.



Mass m travels at constant speed v in a horizontal circle of radius r. What is mass M?

A. $\frac{mv^2}{r}$

B. mv^2rg

C. $\frac{mgv^2}{r}$

D. $\frac{mv^2}{gr}$

$T = Mg$

$T = \frac{mv^2}{r} \Rightarrow Mg = \frac{mv^2}{r}$

$M = \frac{mv^2}{rg}$

23. Planet X has a gravitational field strength of 18 N kg-1 at its surface. Planet Y has the same density as X but three times the radius of X. What is the gravitational field strength at the surface of Y?

A. 6ms-2
B. 18ms-2
C. 54ms-2
D. 162 m s-2

PLANET X

$g = \frac{18\ N}{kg}$

PLANET Y

$g' = ?$

$R_2 = 3R$

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

$$= \frac{G\left[\frac{4}{3}\pi R^3 \rho\right]}{R^2}$$

$$= \frac{4}{3} G R \rho$$

$$\frac{g_1}{g_2} = \frac{\frac{4}{3} G R_1 \rho_1}{\frac{4}{3} G R_2 \rho_2} = \frac{R_1 \rho_1}{R_2 \rho_2}$$

$$= \frac{R}{3R} \frac{\rho}{\rho} = \frac{1}{3}$$

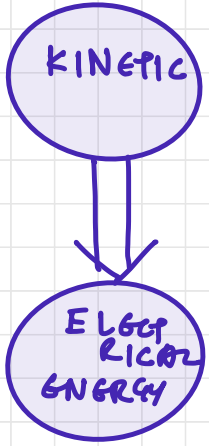
$$g_2 = 3 g_1 = 3(18) = 54\ m s^{-2}$$

24. What are the principal roles of a moderator and of a control rod in a thermal nuclear reactor?

	Role of moderator	Role of control rod
A.	increases kinetic energy of neutrons	maintains a constant rate of reaction
B.	increases kinetic energy of neutrons	absorbs energy transferred in the reactor
C. ✓	reduces kinetic energy of neutrons	maintains a constant rate of reaction
D.	reduces kinetic energy of neutrons	absorbs energy transferred in the reactor

25. A nuclear power station contains an alternating current generator. What energy transfer is performed by the generator?

A. Electrical to kinetic
B. Kinetic to electrical ✓
C. Nuclear to kinetic
D. Nuclear to electrical



26. The average temperature of the surface of a planet is five times greater than the average temperature of the surface of its moon. The emissivities of the planet and the moon are the same. The average intensity radiated by the planet is I. What is the average intensity radiated by its moon?

A. $\frac{I}{25}$

B. $\frac{I}{125}$

C ✓ $\frac{I}{625}$

D. $\frac{I}{3125}$

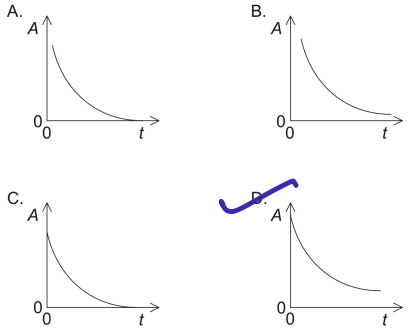
$$I = e\sigma A T^4$$

$$\frac{I_p}{I_m} = \left(\frac{T_p}{T_m}\right)^4$$

$$= \left(\frac{5T_m}{T_m}\right)^4 = 625$$

$$I_m = \frac{I}{625}$$

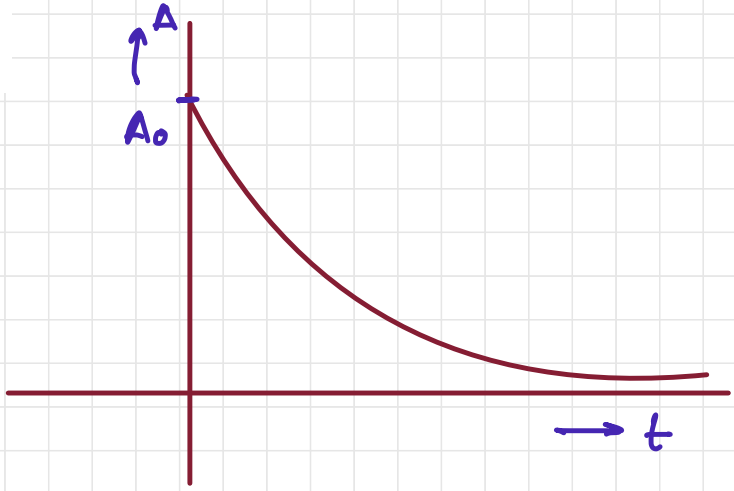
27. Which graph shows the variation of activity A with time t for a radioactive nuclide?



$A = A_0 e^{-t/k}$

at $t = 0$, $A = A_0$

at $t = \infty$, $A \to 0$



28. What statement about alpha particles, beta particles and gamma radiation is true?

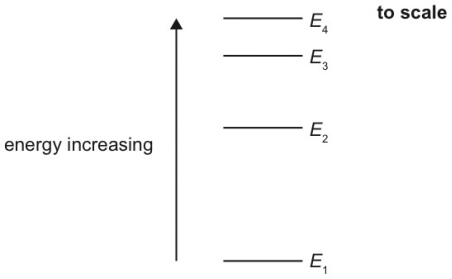
A. Gamma radiation always travels faster than beta particles in a vacuum.

B. In air, beta particles produce more ions per unit length travelled than alpha particles.

C. Alpha particles are always emitted when beta particles are emitted.

D. Alpha particles are deflected in the same direction as beta particles in a magnetic field.

29. Four of the energy states for an atom are shown. Transition between any two states is possible.



What is the shortest wavelength of radiation that can be emitted from these four states?

A. $\frac{hc}{E_4 - E_1}$

B. $\frac{hc}{E_4} - \frac{hc}{E_1}$

C. $\frac{hc}{E_4 - E_3}$

D. $\frac{hc}{E_4} - \frac{hc}{E_3}$

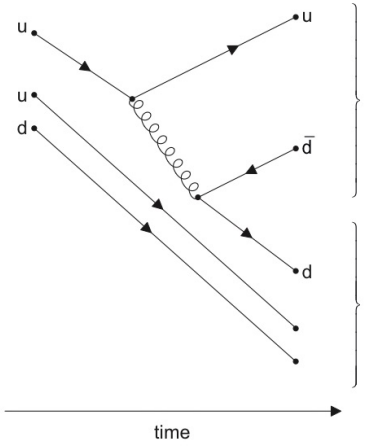
$\Delta E = E_4 - E_1$

$\Delta E = \frac{hc}{\lambda}$

$E_4 - E_1 = \frac{hc}{\lambda}$

$\lambda = \frac{hc}{E_4 - E_1}$

30. The Feynman diagram shows some of the changes in a proton–proton collision.



What is the equation for this collision?

A. $p + p \rightarrow p + n + \pi^+$

B. $p + p \rightarrow p + n + \pi^-$

C. $p + p \rightarrow p + \bar{n} + \pi^+$

D. $p + p \rightarrow p + \bar{n} + \pi^-$

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ROUGH WORK

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