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Physics

Standard level

Paper 1

25 April 2024

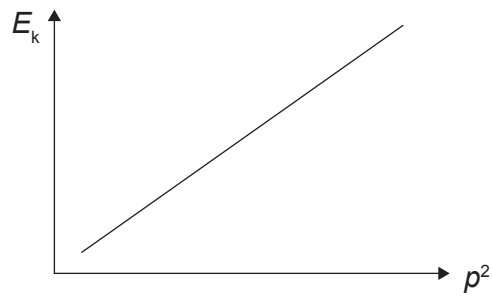
Zone A afternoon | Zone B afternoon | Zone C afternoon

45 minutes

Instructions to candidates

- Do not open this examination paper until instructed to do so.
- Answer all the questions.
- For each question, choose the answer you consider to be the best and indicate your choice on the answer sheet provided.
- A clean copy of the **physics data booklet** is required for this paper.
- The maximum mark for this examination paper is **[30 marks]**.

1. The graph shows the variation of kinetic energy E_k with momentum squared p^2 .



What are the fundamental SI units for the gradient of the graph?

- A. kg^{-1}
 - B. kg
 - C. Jm^2s^{-2}
 - D. Jms^{-1}
2. A cart accelerates from $(20 \pm 1) \text{ms}^{-1}$ to $(30 \pm 1) \text{ms}^{-1}$.

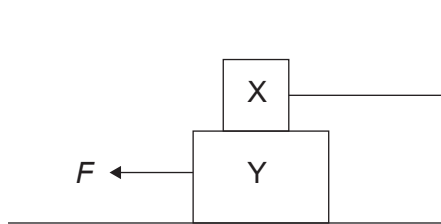
What is the percentage uncertainty in the change of speed of the cart?

- A. 2%
- B. 4%
- C. 8%
- D. 20%

3. Jim runs with a constant velocity v past Sally who is at rest. At this instant, Sally begins to chase Jim with constant acceleration a .

Which expression gives the time Sally will catch Jim?

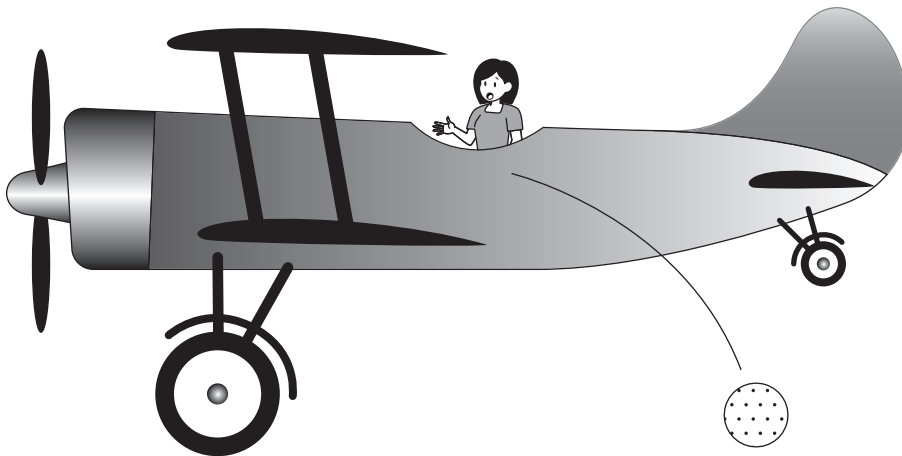
- A. $\frac{v}{2a}$
- B. $\frac{v}{a}$
- C. $\frac{2v}{a}$
- D. $\frac{4v}{a}$
4. A block X of weight 10 N is stacked on a block Y of weight 20 N. Block X is fixed to a wall with a light string. The coefficients of static friction between the blocks and between block Y and the ground are both 0.2.



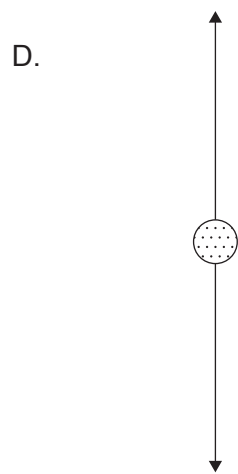
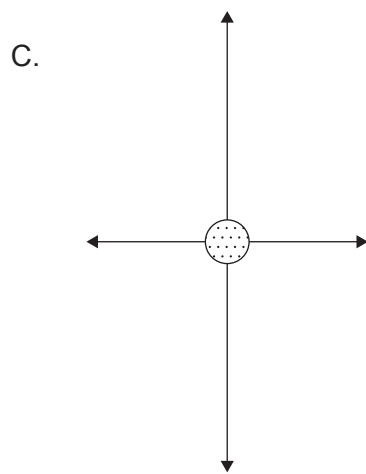
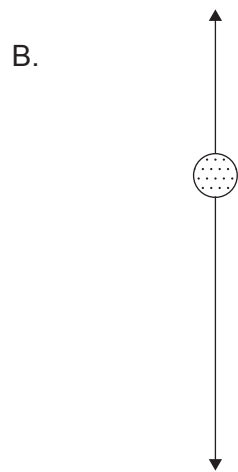
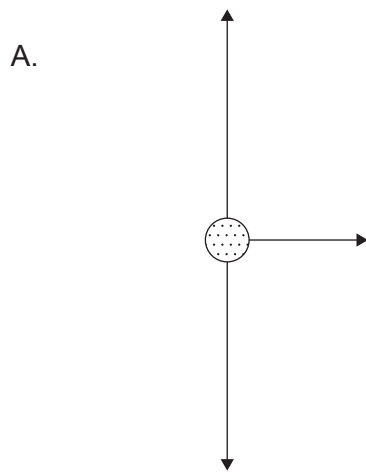
What is the value of the minimum force F required to move block Y and what is the tension T in the string immediately before block Y begins to move?

| | Minimum force F/N | Tension in string T/N |
|----|------------------------|----------------------------|
| A. | 8 | 2 |
| B. | 8 | 6 |
| C. | 6 | 2 |
| D. | 6 | 6 |

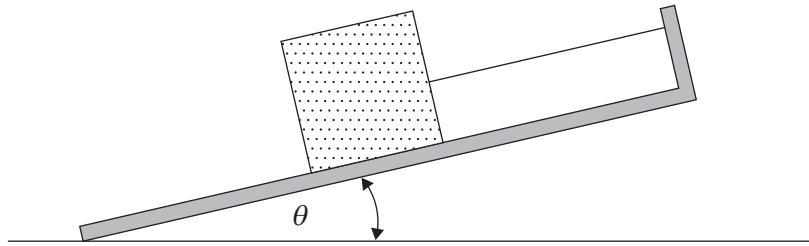
5. A ball is thrown from an aircraft in flight.



Which of the following shows the correct free-body diagram for the forces acting on the ball when terminal velocity is reached?

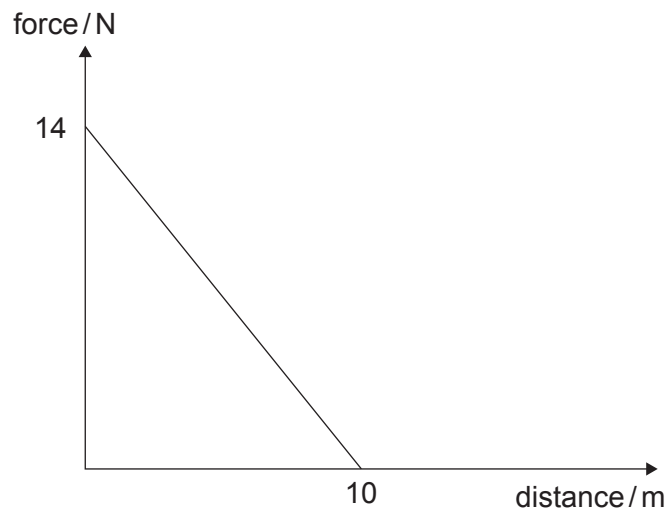


6. An object is held in position by a light string on an incline plane such that the angle θ to the horizontal is slowly increased from zero.



Which statement is **correct** about the forces acting on the object as the angle θ is increased?

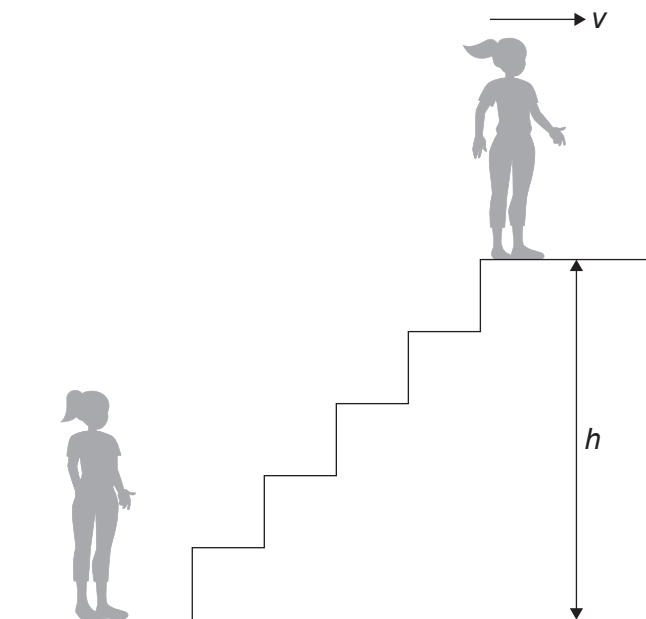
- A. The tension in the string remains constant.
 - B. The normal force decreases.
 - C. The weight component parallel to the slope remains constant.
 - D. The weight decreases.
7. A mass of 4.0 kg moving with a velocity of 1.0 ms^{-1} is acted on by a net force which varies with distance as shown.



What is the maximum speed of the mass?

- A. $\sqrt{35}\text{ ms}^{-1}$
- B. 6 ms^{-1}
- C. $\sqrt{71}\text{ ms}^{-1}$
- D. 12 ms^{-1}

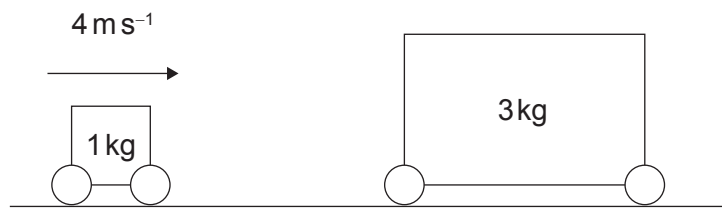
8. A student of mass m initially at rest takes t seconds to run up stairs of height h . At the top of the stairs the student has a velocity v .



What is the average power supplied by the student during the climb?

- A. $\frac{mgh}{t}$
- B. $\frac{m\left(gh + \frac{1}{2}v^2\right)}{t}$
- C. $\frac{m\left(gh - \frac{1}{2}v^2\right)}{t}$
- D. mgv

9. A cart of mass 1 kg moving at 4 m s^{-1} collides with a stationary cart of mass 3 kg.

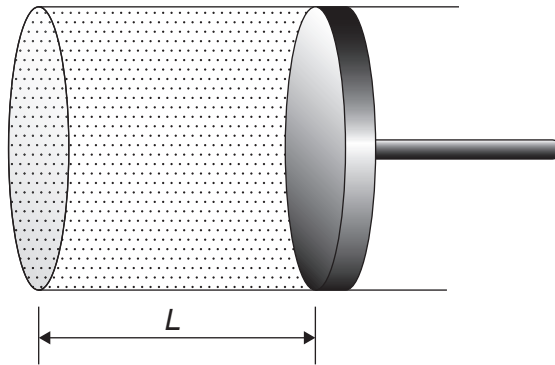


After the collision the carts stick together.

What is $\frac{\text{kinetic energy after the collision}}{\text{kinetic energy before the collision}}$?

- A. $\frac{1}{16}$
- B. $\frac{1}{8}$
- C. $\frac{1}{4}$
- D. $\frac{1}{2}$

10. An ideal gas is sealed in a cylinder with a sliding piston. When the piston is a length L from the bottom of the cylinder the total force of the gas particles on the piston is F_{total} and the average force each individual particle imparts on the piston per collision is F_{particle} .

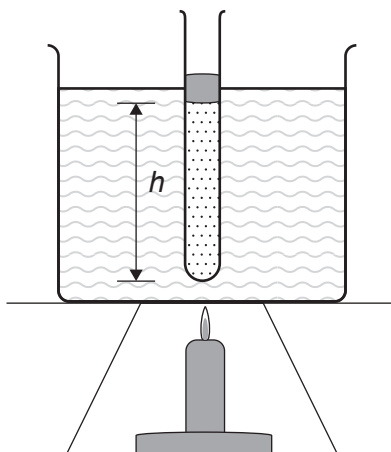


The piston length is slowly reduced to $\frac{L}{2}$ such that the temperature of the gas remains constant.

What is true about the change in F_{total} and the change in F_{particle} ?

| | Change in F_{total} | Change in F_{particle} |
|----|------------------------------|---------------------------------|
| A. | Increase | No change |
| B. | Increase | Increase |
| C. | No change | No change |
| D. | No change | Increase |

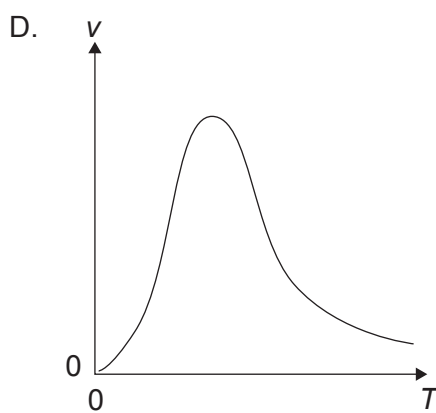
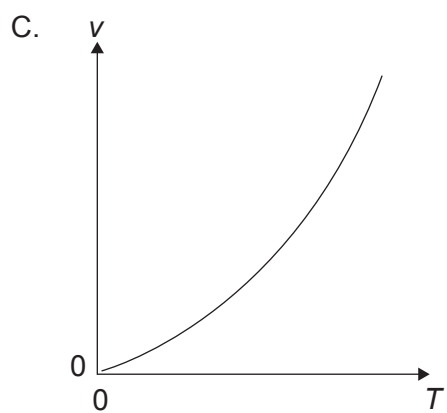
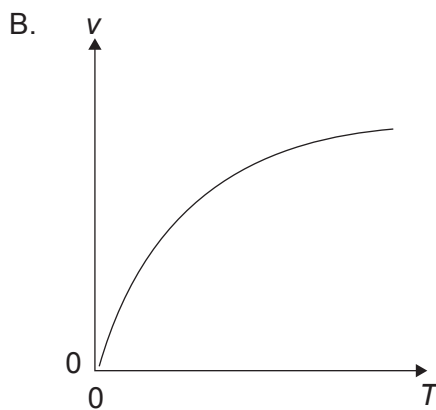
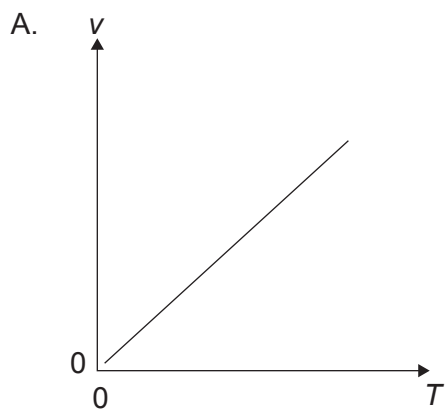
11. A layer of mercury traps a volume of gas in a tube. The tube is placed in a water bath and slowly heated. When the temperature of the water is 300K the height of gas h in the tube is 150 mm.



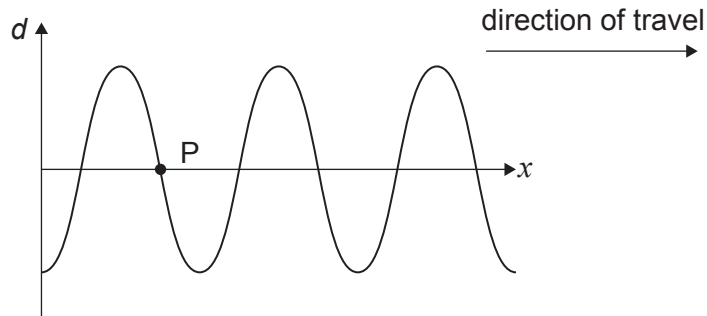
What is h when the temperature of the water is 360K?

- A. 120 mm
- B. 180 mm
- C. 300 mm
- D. 360 mm

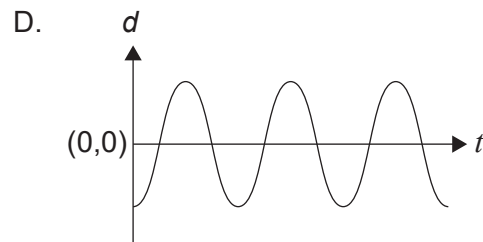
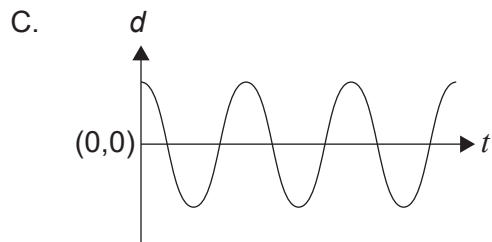
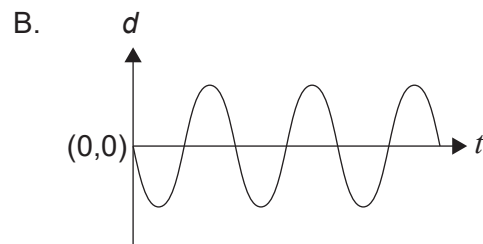
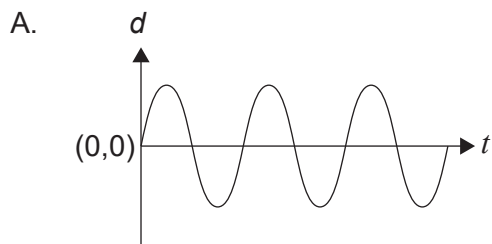
12. Which graph shows the variation of molecular speed v with absolute temperature T of an ideal gas?



13. The graph shows the variation of displacement d with distance x along a transverse wave. At time $t = 0$ a point P has a displacement $d = 0$.



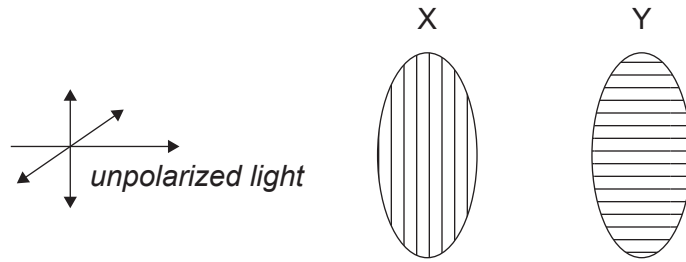
Which of the graphs shows the variation with time t of the displacement d of P?



14. Which statement is **incorrect** about a standing wave?

- A. All points between adjacent nodes oscillate in phase.
- B. The wave must always reflect out of phase at a boundary.
- C. The frequency is the same at each point.
- D. The wavelength is twice the distance between adjacent nodes.

15. Unpolarized light is incident on two polarizers X and Y. The transmission axis of X is vertical and that of Y is horizontal.



Polarizer Z can be placed

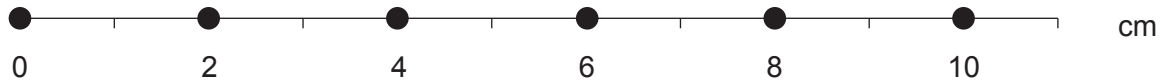
- I. before polarizer X.
- II. between polarizer X and Y.
- III. after polarizer Y.

The transmission axis of Z makes an angle of 45° with those of X and Y.

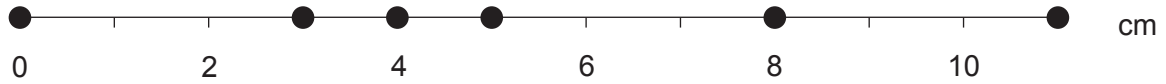
At which positions for Z will no light be transmitted?

- A. I and II only
- B. I and III only
- C. II and III only
- D. I, II and III

16. The equilibrium positions of six particles in a medium are separated by a distance of 2 cm as shown.



The positions of these particles, when a longitudinal wave is transmitted through the medium, are now shown.



What is the wavelength of the wave?

- A. 2 cm
 - B. 4 cm
 - C. 6 cm
 - D. 8 cm
17. Light passes from a medium into air. The critical angle is θ_c .

Which expression gives the speed of light in the medium?

- A. $\frac{1}{c \sin \theta_c}$
- B. $\frac{\sin \theta_c}{c}$
- C. $\frac{c}{\sin \theta_c}$
- D. $c \sin \theta_c$

18. Three statements are made about drift speed v_d in a metal wire.

- I. v_d is less than the speed of light in a vacuum.
- II. v_d is the average speed of positive lattice ions.
- III. v_d is directly proportional to the current.

Which statements are correct?

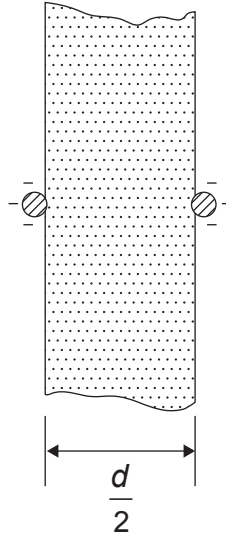
- A. I and II only
- B. I and III only
- C. II and III only
- D. I, II and III

19. Current I flows in a conducting wire.

What expression correctly gives the number of electrons passing through a cross section of the wire in a time t ?

- A. It
- B. $\frac{I}{t}$
- C. Ite
- D. $\frac{It}{e}$

20. Two point charges of equal charge are separated in free space by a distance d and experience an electric force $F_{\text{free space}}$. The same point charges are now separated by a wall of concrete $\frac{d}{2}$ thick and experience an electric force F_{concrete} .

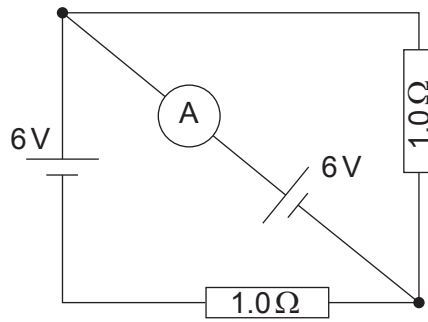


The permittivity of concrete is four times that of free space.

What is $\frac{F_{\text{concrete}}}{F_{\text{free space}}}$?

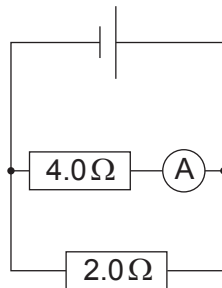
- A. $\frac{1}{4}$
- B. $\frac{1}{2}$
- C. 1
- D. 8

21. Two 1.0Ω resistors are placed in a circuit with two 6V cells of negligible internal resistance as shown.



What is the reading on the ideal ammeter?

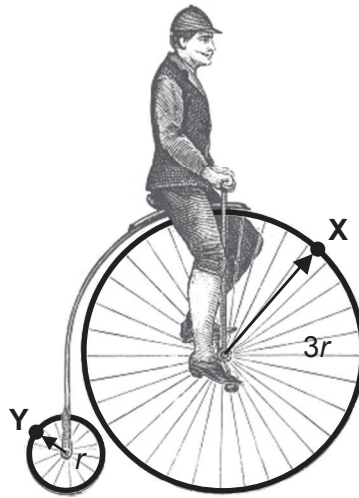
- A. 2.0A
 - B. 3.0A
 - C. 6.0A
 - D. 12.0A
22. A 2.0Ω and a 4.0Ω resistor are connected in parallel to a cell with negligible internal resistance. An ammeter placed in the circuit as shown measures a current of 1.0A .



What is the current passing through the 2.0Ω resistor?

- A. 0.5A
- B. 1.0A
- C. 2.0A
- D. 4.0A

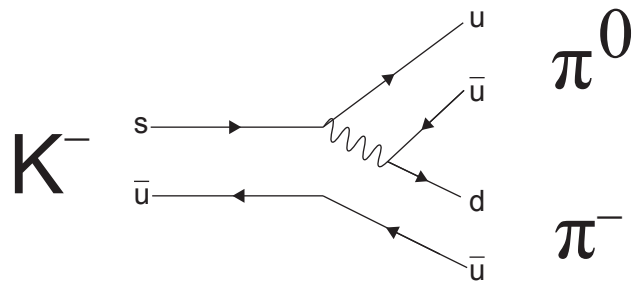
23. An old-fashioned bicycle is moving with a constant speed v . The front wheel has a radius 3 times that of the rear wheel. Points X and Y are positioned on the front and rear wheel as shown.



What is $\frac{\text{acceleration of X}}{\text{acceleration of Y}}$?

- A. $\frac{1}{9}$
- B. $\frac{1}{3}$
- C. 3
- D. 9

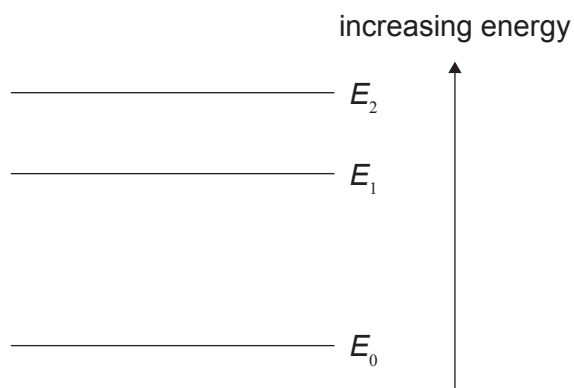
24. The Feynman diagram shows a possible decay of a K^- meson.



Which particle is represented by the wavy line?

- A. Gluon
- B. Z^0
- C. Photon
- D. W^-

25. Three electron energy levels of a gas atom E_0 , E_1 and E_2 are shown.



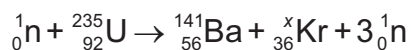
The following three claims are made about photons associated with these energy levels:

- I. Transition from E_2 to E_1 will produce photons with the shortest wavelength.
- II. Transition from E_2 to E_0 will produce photons with the highest frequency.
- III. Three lines in the spectrum of this gas appear.

Which statements are **correct**?

- A. I and II only
- B. I and III only
- C. II and III only
- D. I, II and III

26. A nucleus of uranium undergoes fission.



What is correct about the number of nucleons x in the Kr nucleus and the ratio

$\frac{\text{binding energy per nucleon of Kr}}{\text{binding energy per nucleon of Ba}}$?

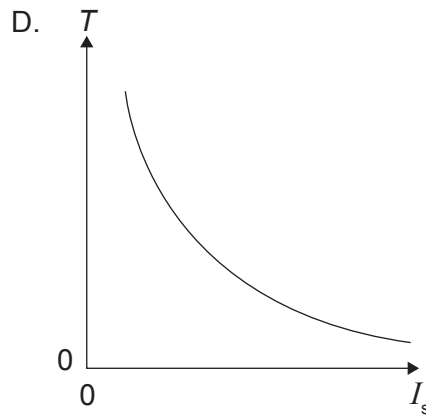
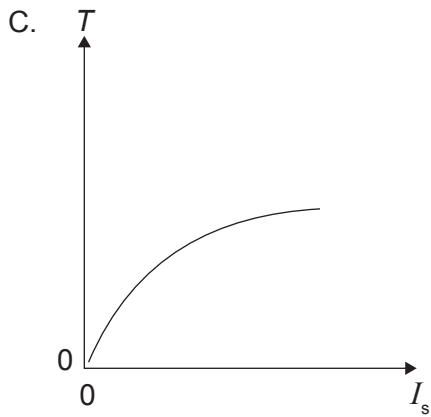
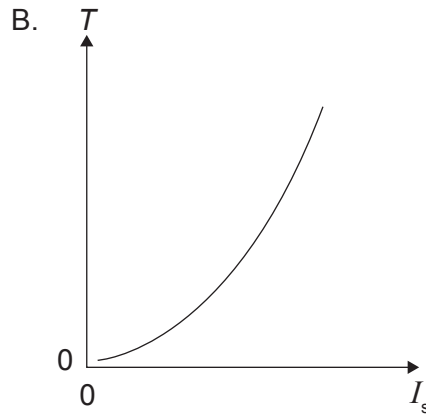
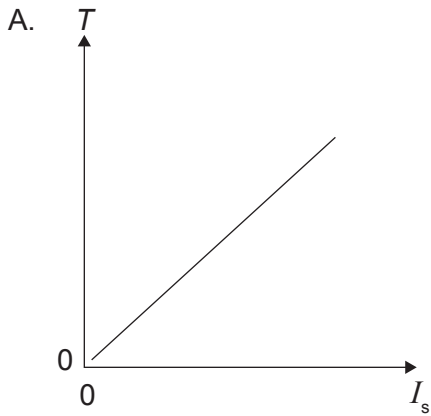
| | Number of nucleons x in Kr nucleus | $\frac{\text{binding energy per nucleon of Kr}}{\text{binding energy per nucleon of Ba}}$ |
|----|---|---|
| A. | 92 | Greater than 1 |
| B. | 92 | Less than 1 |
| C. | 94 | Greater than 1 |
| D. | 94 | Less than 1 |

27. The half-life of a radioactive substance is 5 hours. At time $t = 20$ hours N nuclei are present in the sample.

What was the number of radioactive nuclei that were present at time $t = 5$ hours?

- A. $3N$
- B. $4N$
- C. $8N$
- D. $9N$

28. A planet has a known albedo and emissivity. The average intensity received at the surface is I_s . Which graph describes the variation of surface temperature T with I_s ?



29. The wind generator equation can be used to estimate the power produced by a wind turbine from a given set of conditions.

Which assumption is **not** used in the derivation of this equation?

- A. The number of blades on the turbine is a constant.
- B. Speed of air particles after passing through the turbine is zero.
- C. Speed of air particles approaching the turbine cross-sectional area is constant.
- D. Turbulence created by the spinning turbine is negligible

30. An engine provides a thrust force F to move a vehicle at constant velocity v . The engine has an efficiency e and consumes fuel with an energy density η .

Which expression gives the rate at which the volume of fuel is being consumed by the engine?

- A. $\frac{Fv}{e\eta}$
- B. $\frac{Fv\eta}{e}$
- C. $\frac{eFv}{\eta}$
- D. $\frac{e\eta}{Fv}$
-

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References:

23. Clu, n.d. *Penny farthing bicycle*. [image online] Available at: <https://www.gettyimages.co.uk/detail/illustration/penny-farthing-bicycle-first-exercise-royalty-free-illustration/1179950344> [Accessed 16 May 2023]. Source adapted.

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