PHYSICS SL

Thursday 19 June 2015

Content : 8 IB's Problems of Papers two

Part I

Name: _____

Problem 1 ***[10 marks]***

(a) State the nature of an α-particle. *[1]*

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(b) In the Rutherford-Geiger-Marsden experiment to investigate the structure of the atom, α-particles were directed towards a gold foil. Explain why α-particles, rather than electrons, were used in this experiment. *[2]*

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(c) Uranium-238 $\left({}^{238}_{92}\mathrm{U}\right)$ undergoes α-decay to form thorium (Th). The half-life of uranium ${}^{238}_{92}\mathrm{U}$ is 4.5×10^{9} years.

(i) Define *half-life*. *[2]*

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(ii) Write down the nuclear equation for the α-decay of uranium to thorium. *[2]*

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(d) Thorium is radioactive and further decays occur, eventually giving lead which is stable. These further decays all occur within a time that is short compared to the half-life of ${}^{238}_{92}\mathrm{U}$. In a sample of rocks the ratio of the number of uranium atoms to the number of lead atoms is $\frac{1}{7}$.

(i) Estimate the age of the rocks assuming that no lead was initially present in the rocks. *[2]*

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(ii) State **one** further assumption that is made in this estimate. *[1]*

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Problem 2 *[12 marks]*

(a) The nucleon number (mass number) of a stable isotope of argon is 36 and of a radioactive isotope of argon is 39.

(i) State what is meant by a *nucleon*. *[1]*

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(ii) Explain, in terms of the number of nucleons and the forces between them, why argon-36 is stable and argon-39 is radioactive. *[4]*

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(b) A particular nucleus of argon-39 undergoes the decay shown by the nuclear reaction equation below.

$$^{39}_{18}\mathrm{Ar} \rightarrow \mathrm{K} + \beta^{-}$$

(i) State the proton (atomic) number and the nucleon (mass) number of the potassium (K) nucleus. *[2]*

Proton number: . . . . . .

Nucleon number: . . . . . .

(ii) Use the following data to determine the maximum energy, in J, of the β^{-} particle in the decay of a sample of argon-39. *[3]*

Mass of argon-39 nucleus = 38.96431 u
Mass of K nucleus = 38.96370 u

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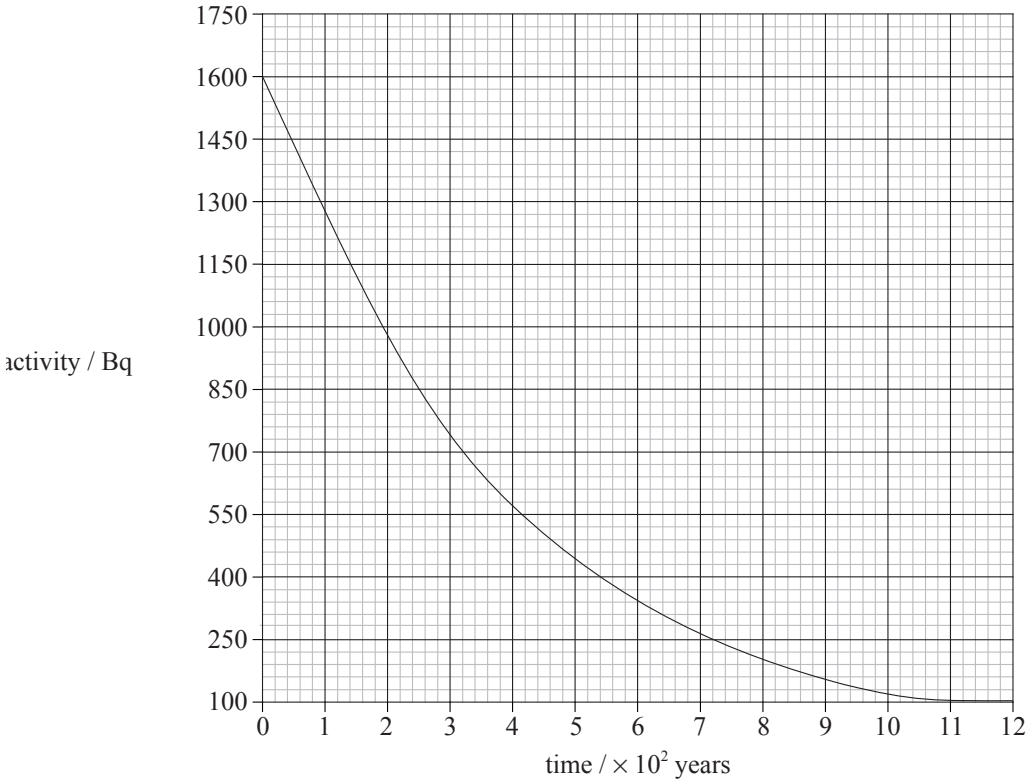
(This question continues on the following page)

(c) The graph below shows the variation with time t of the activity A of a sample of argon-39.



Use the graph to determine the half-life of argon-39. Explain your reasoning. *[2]*

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Problem 3 *[10 marks]*

(a) A nucleus of radium-91 $\left({}^{226}_{91}\mathrm{Ra}\right)$ undergoes alpha particle decay to form a nucleus of radon (Rn).

(i) Identify the proton number and nucleon number of the nucleus of Rn. *[2]*

Proton number: . . . . . .

Nucleon number: . . . . . .

(ii) The half-life of radium-91 is 1600 years. Determine the length of time taken for 87.5% of the radium to disintegrate. *[2]*

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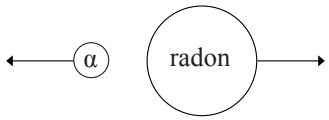
(b) Immediately after the decay of a stationary radium nucleus, the alpha particle and the radon nucleus move off in opposite directions and at different speeds.



Outline the reasons for these observations. *[3]*

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(c) Outline why a beta particle has a longer range in air than an alpha particle of the same energy. *[3]*

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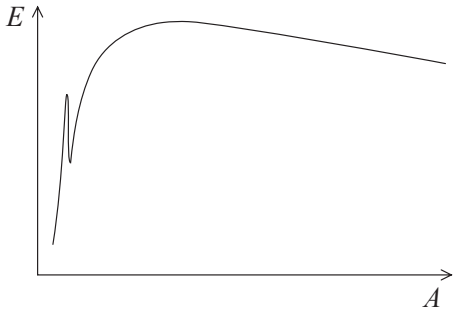
Problem 4 *[5 marks]*

The sketch graph below shows the variation with mass number (nucleon number) A of the binding energy per nucleon E of nuclei.



One possible nuclear reaction that occurs when uranium-235 is bombarded by a neutron to form xenon-142 and strontium-90 is represented as

$$^{235}_{92}\mathrm{U} + {}^{1}_{0}\mathrm{n} \rightarrow {}^{142}_{54}\mathrm{Xe} + {}^{90}_{38}\mathrm{Sr} + 4\,{}^{1}_{0}\mathrm{n}.$$

(i) Identify the type of nuclear reaction represented above. *[1]*

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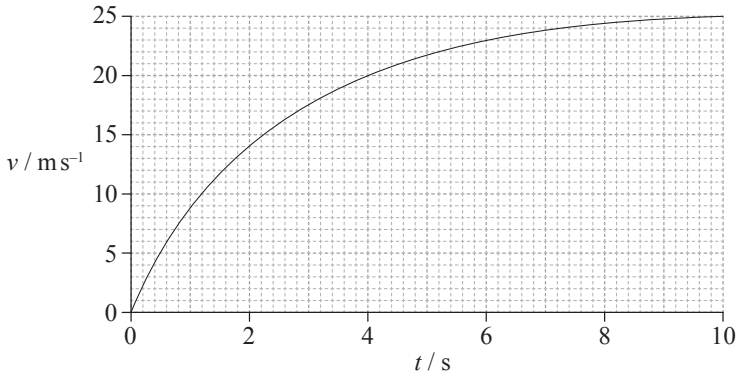
(ii) On the sketch graph above, identify with their symbols the approximate positions of the uranium (U), the xenon (Xe) and the strontium (Sr) nuclei. *[2]*

(iii) Which of all nucleus is know to have the greatest stability ?

Give its approximate position on the sketch graph above. *[2]*

Problem 5 ***[15 marks]***

The graph shows the variation with time t of the speed v of a ball of mass 0.50 kg, that has been released from rest above the Earth's surface.



The force of air resistance is **not** negligible. Assume that the acceleration of free fall is $g = 9.81\,\text{m s}^{-2}$.

(a) State, without any calculations, how the graph could be used to determine the distance fallen. *[1]*

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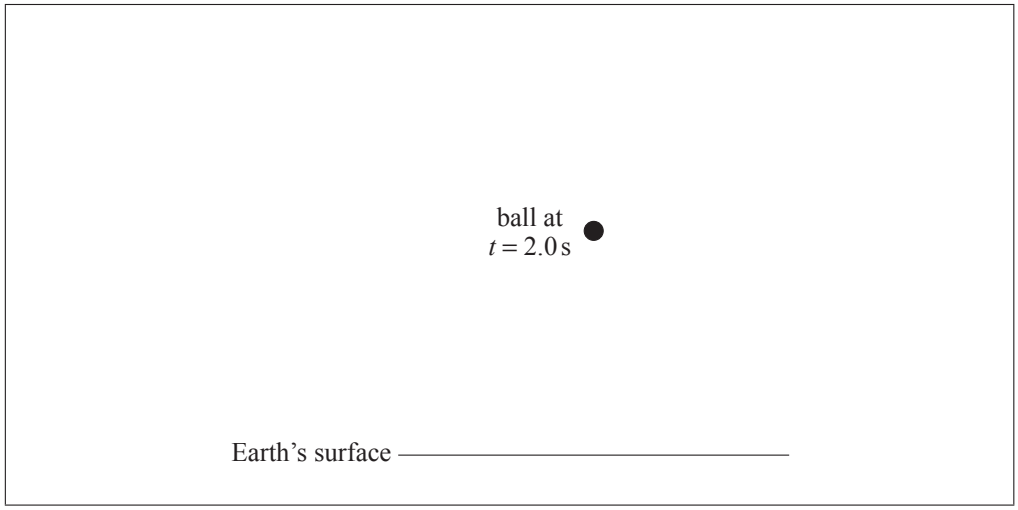
(b) (i) In the space below, draw and label arrows to represent the forces on the ball at 2.0 s. *[1]*



(ii) Use the graph opposite to show that the acceleration of the ball at 2.0 s is approximately $4\,m\,s^{-2}$. *[2]*

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(iii) Calculate the magnitude of the force of air resistance on the ball at 2.0 s. *[2]*

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(iv) State and explain whether the air resistance on the ball at $t = 5.0$ s is smaller than, equal to **or** greater than the air resistance at $t = 2.0$ s. *[2]*

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(c) After 10 s the ball has fallen 190 m.

(i) Show that the sum of the potential and kinetic energies of the ball has decreased by 780 J. *[3]*

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(ii) The specific heat capacity of the ball is 480 J kg^{-1} K^{-1}. Estimate the increase in the temperature of the ball. *[2]*

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(iii) State an assumption made in the estimate in (c)(ii). *[1]*

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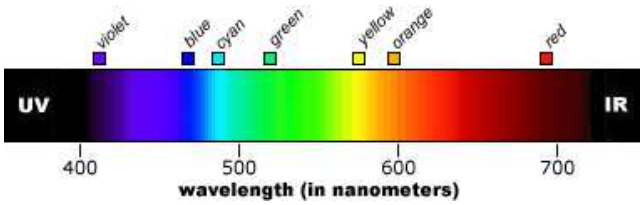
Problem 6 *[15 marks]*

Each colour has a different wavelenght and therefor a different frequency, for example in vacuum:



For this question, we will assume that for a given optical material, the refractive index of depends of the frequency. That implies the refracive angle ar fifferent for red, blue and yellow.

(a) Define the term *refractive index* as applied to an optical material *[2]*

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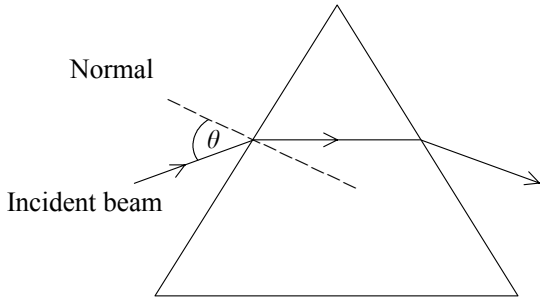
The diagram below shows the path followed by a ray of red light that is incident on one face of a glass prism at an angle θ to the normal.



(b) (i) The red light is now replaced by blue light. *[2]*

On the diagram sketch the corresponding path followed by a ray of blue light incident at the same angle θ.

(ii) State and explain whether the *refractive index* for *red* light in the glass is *greater* than, *equal* or *smaller* than the *refractive index* of the *blue* light. *[2]*

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(c) Let us condider a ray of *red* light with wavelenght $\lambda = 680$ nm. (in vaccuum) *[2]*

What is its wavelenght in glass (of refractive index $n = 1.6$) ?

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(d) Which side of the prism as shown above we could perhaps observe a *total reflexion* ?

(*left side*, *right side* or *horizontal bottom* ? Explain !) *[2]*

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(e) That could be possiblbe by *increasing* of *decreasing* angle θ ? *[1]*

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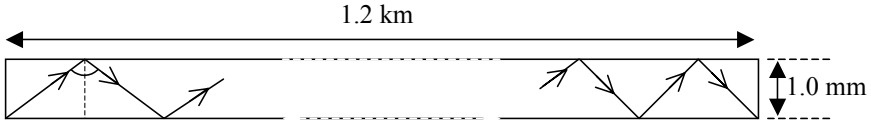
(f)

A straight optic fibre has length 1.2 km and diameter 1.0 mm. Light is reflected along the fibre as shown below.



At each reflection, the angle of incidence is equal in value to the critical angle. The refractive index of the glass of the fibre is 1.5.

Deduce that the lenght of the light path along the optic fibre is about 1.8 km. *[4]*

Problem 7 *[9 marks]*

(a) Define *specific latent heat of fusion*. *[1]*

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(b) Solar radiation is incident on a pond of area $12\,m^2$. The pond is covered by a layer of ice of thickness 3.0 cm. The temperature of the ice is 0.0 °C.

(i) The density of ice is $900\,kg\,m^{-3}$. Deduce that the mass of ice on the pond is approximately 320 kg. *[2]*

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(ii) The average power per unit area incident on the ice over a period of 6.0 hours is $340\,W\,m^{-2}$. Deduce that the energy incident on the pond in this time is 8.8×10^7 J. *[1]*

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(iii) The specific latent heat of fusion of ice is $330\,kJ\,kg^{-1}$. Determine whether all the ice on the pond will melt in the 6.0 hour time period. *[2]*

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(iv) State **one** assumption you made in reaching your answer to (b)(iii). *[1]*

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(c) During the night, the air temperature drops to –5 °C. The ice that melted during the day freezes again. Outline **one** mechanism by which thermal energy is lost by the ice. *[2]*

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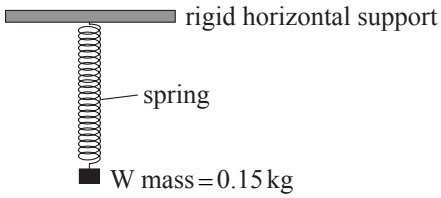
Problem 8 *[10 marks]*

(a) One end of a light spring is attached to a rigid horizontal support.



An object W of mass 0.15 kg is suspended from the other end of the spring. The extension x of the spring is proportional to the force F causing the extension. The force per unit extension of the spring k is $18\,\text{N m}^{-1}$.

A student pulls W down such that the extension of the spring increases by 0.040 m. The student releases W and as a result W performs simple harmonic motion (SHM).

(i) State what is meant by the expression "W performs SHM". *[2]*

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(ii) Determine the maximum acceleration of W. *[2]*

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(iii) Determine the period of oscillation of the spring. *[3]*

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(iv) Determine the maximum kinetic energy of W. *[1]*

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(b) W in (a) is immersed in a beaker of oil. As a result of this immersion the oscillations of W are critically damped. Describe what is meant by critically damped. *[2]*

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(c) A spring, such as that in (a), is stretched horizontally and a longitudinal travelling wave is set up in the spring, travelling to the right.

(i) Describe, in terms of the propagation of energy, what is meant by a longitudinal travelling wave. *[2]*

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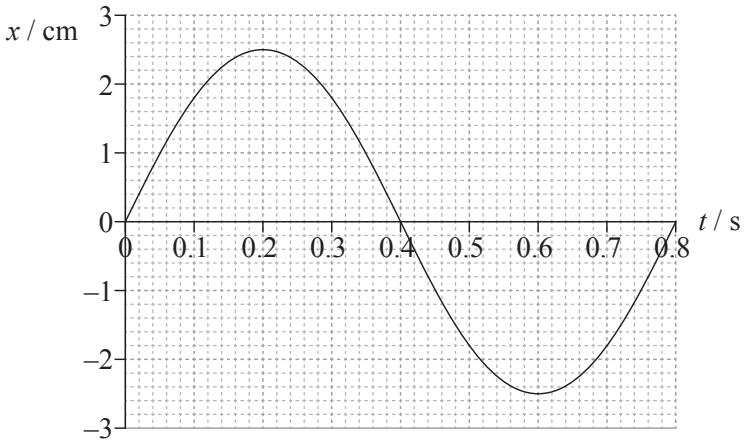
(ii) The graph shows how the displacement x of one coil C of the spring varies with time t.



The speed of the wave is $3.0\,\text{cm}\,\text{s}^{-1}$. Determine the wavelength of the wave. *[2]*

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(iii) Draw, on the graph in (c)(ii), the displacement of a coil of the spring that is 1.8 cm away from C in the direction of travel of the wave, explaining your answer. *[2]*

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Content : 20 IB's Problems of Papers one

Part II

(The questions 1 to 14 come from the same IB Paper 1 May 2014 , the last one from BI 2007 & 2011)

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1. Which of the following is a unit of energy?

A. $\mathrm{kg\,m^{-1}\,s^{-1}}$

B. $\mathrm{kg\,m^{2}\,s^{-2}}$

C. $\mathrm{kg\,m\,s^{-2}}$

D. $\mathrm{kg\,m^{2}\,s^{-1}}$

2. Each side of a metal cube is measured to be $2.0\,\mathrm{cm} \pm 0.20\,\mathrm{cm}$. What is the absolute uncertainty in the calculated volume of the cube?

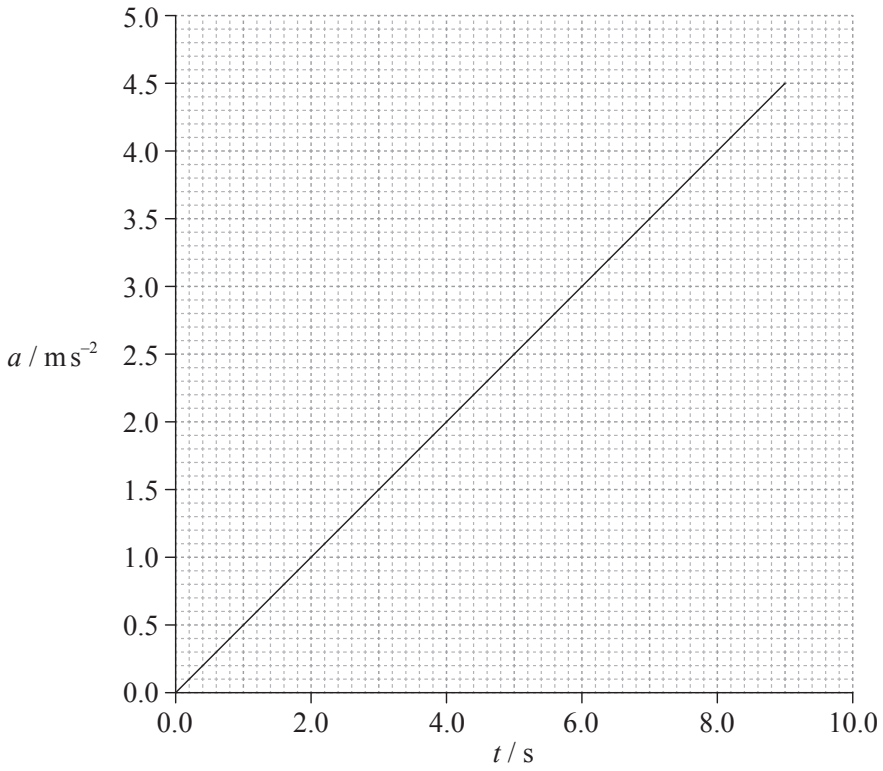
A. $\pm 0.08\,\mathrm{cm^3}$

B. $\pm 0.60\,\mathrm{cm^3}$

C. $\pm 0.80\,\mathrm{cm^3}$

D. $\pm 2.4\,\mathrm{cm^3}$

3. A particle accelerates from rest. The graph shows how the acceleration a of the particle varies with time t.



What is the speed of the particle at $t = 6.0\,\text{s}$?

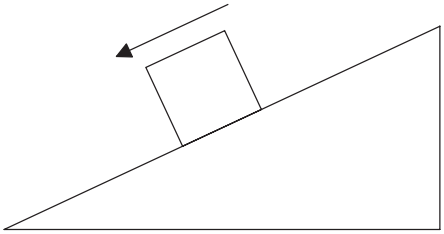
A. $0.5\,\text{m s}^{-1}$

B. $2.0\,\text{m s}^{-1}$

C. $9.0\,\text{m s}^{-1}$

D. $18\,\text{m s}^{-1}$

4. A block slides down an inclined plane at constant speed.



Which diagram represents the free-body diagram of the forces acting on the block?

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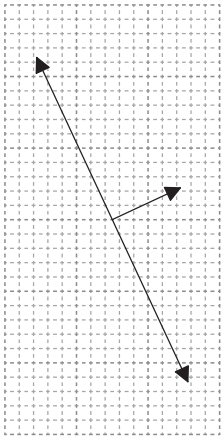
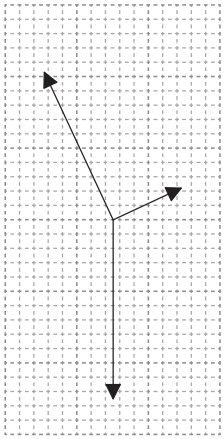
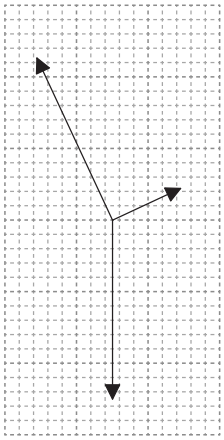


B.



C.



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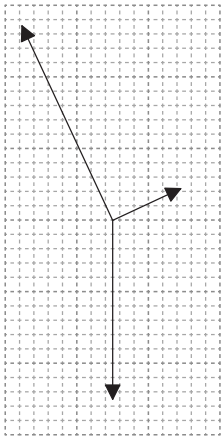


5. In the collision between two bodies, Newton's third law

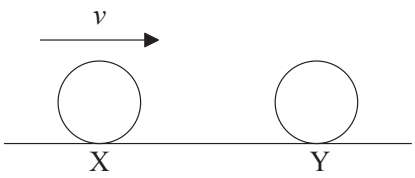
A. only applies if momentum is conserved in the collision.

B. only applies if energy is conserved in the collision.

C. only applies if both momentum and energy are conserved in the collision.

D. always applies.

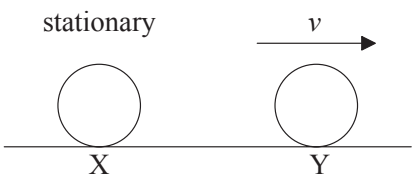
6. A ball X moving horizontally collides with an identical ball Y that is at rest.



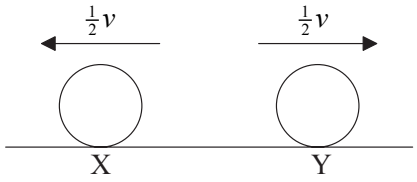
X strikes Y with speed v.

What is a possible outcome of the collision?

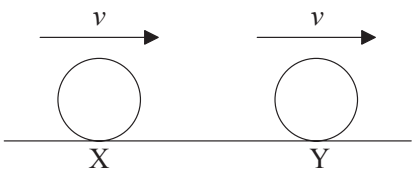
A.



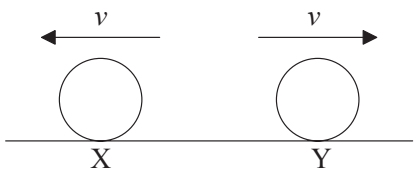
B.



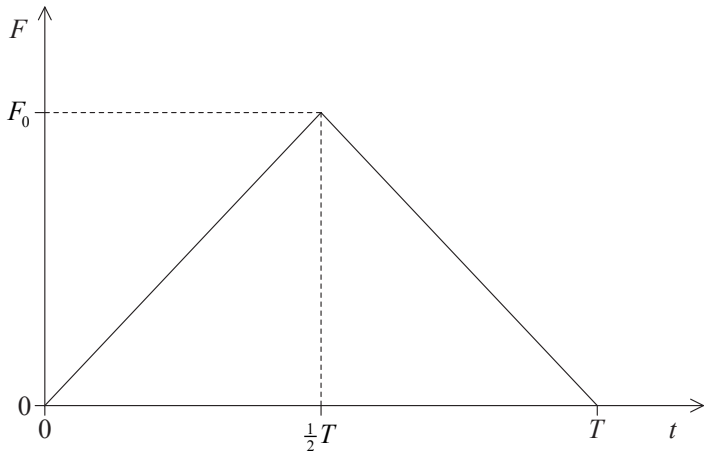
C.



D.



7. A ball is moving horizontally and strikes a vertical wall from which it rebounds horizontally. The sketch graph shows how the contact force F between ball and wall varies with time of contact t.



The maximum value of F is F_0 and the total time of contact between ball and wall is T.

What is the change in momentum of the ball?

A. $\frac{F_0 T}{2}$

B. $F_0 T$

C. $\frac{F_0}{2T}$

D. $\frac{F_0}{T}$

8. An insect of mass m jumps vertically from rest to a height h. The insect releases the energy needed for the jump in time Δt. What is the estimate for the power developed by the insect?

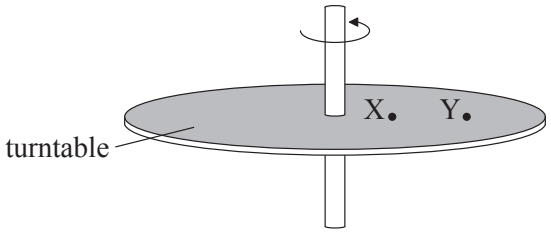
A. $mgh\,\Delta t$

B. $mh\,\Delta t$

C. $\frac{mgh}{\Delta t}$

D. $\frac{mh}{\Delta t}$

9. Two particles, X and Y, are attached to the surface of a horizontally mounted turntable.



The turntable rotates uniformly about a vertical axis. The magnitude of the linear velocity of X is v and the magnitude of its acceleration is a. Which of the following correctly compares the magnitude of the velocity of Y and the magnitude of the acceleration of Y with v and a respectively?

	Magnitude of velocity of Y	**Magnitude of acceleration of Y**
A.	equal to v	less than a
B.	greater than v	less than a
C.	equal to v	greater than a
D.	greater than v	greater than a

10. Two objects are in thermal contact. For there to be no net transfer of thermal energy between the objects they must

A. have the same thermal capacity and be at the same temperature.

B. have the same thermal capacity only.

C. have the same mass and be at the same temperature.

D. be at the same temperature only.

11. The specific latent heat is the energy required to change the phase of

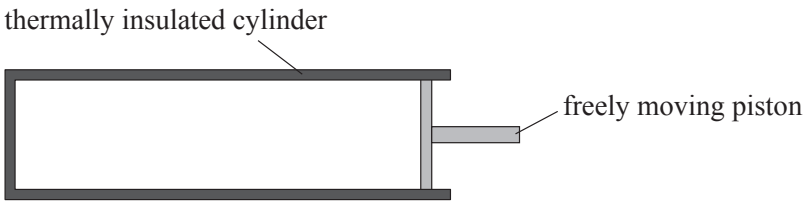
A. one kilogram of a substance.

B. a substance at constant temperature.

C. a liquid at constant temperature.

D. one kilogram of a substance at constant temperature.

12. An ideal gas is contained in a thermally insulated cylinder by a freely moving piston.



The gas is compressed by the piston and as a result the temperature of the gas increases. What is the explanation for the temperature rise?

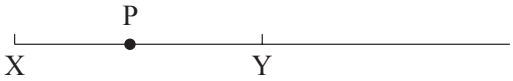
A. The rate of collision between the molecules increases.

B. Energy is transferred to the molecules by the moving piston.

C. The molecules of the gas are pushed closer together.

D. The rate of collision between the molecules and the walls of the cylinder increases.

13. A particle P executes simple harmonic motion (SHM) about its equilibrium position Y.



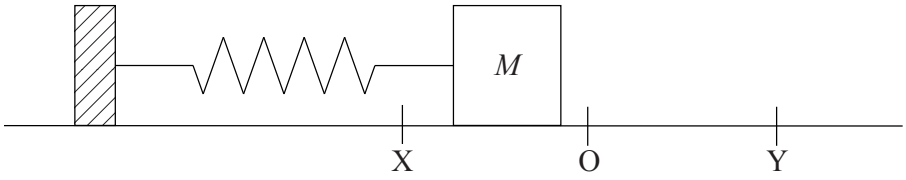
The amplitude of the motion is XY.

At which of the positions shown on the diagram is the acceleration of P equal to zero and the kinetic energy of P equal to zero?

	Acceleration	Kinetic energy
A.	Y	X
B.	X	X
C.	Y	Y
D.	X	Y

14.

A system, consisting of a mass *M* connected to a spring, oscillates on a frictionless surface with simple harmonic motion between two points, X and Y. Point O is the centre of the oscillation.



For the system, at which of the following points is the elastic potential energy equal to the kinetic energy?

A. O only

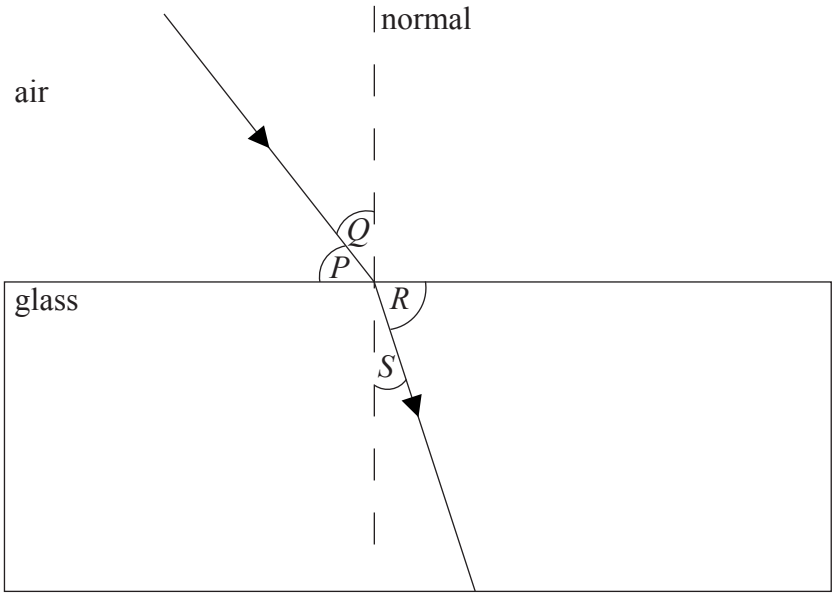
B. X and Y only

C. O, X and Y

D. Neither O, X nor Y

15.

Light travels from air into glass as shown below.



What is the refractive index of glass?

A. $\frac{\sin P}{\sin S}$

B. $\frac{\sin Q}{\sin R}$

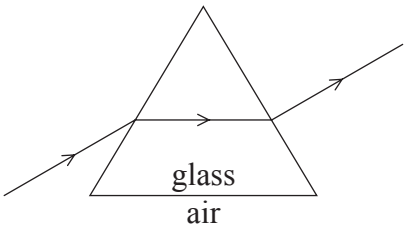
C. $\frac{\sin P}{\sin R}$

D. $\frac{\sin Q}{\sin S}$

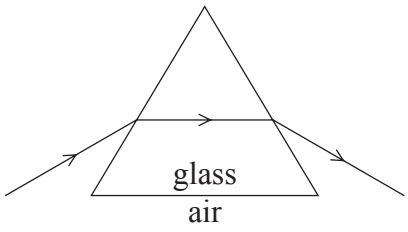
16.

Which of the following diagrams best shows the path of a ray of monochromatic light through a glass prism in air?

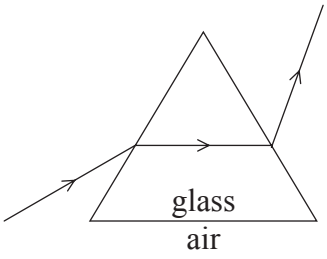
A.



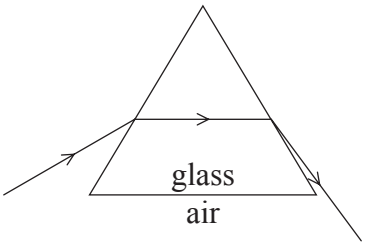
B.



C.



D.



17.

Which of the following statements best describes the **random** nature of radioactive decay?

A. The decaying nucleus emits either an α-particle, or a β-particle or a γ-ray photon.

B. The type of radiation emitted by the decaying nucleus cannot be predicted.

C. The time at which a particular nucleus will decay cannot be predicted.

D. The decay of a nucleus is unaffected by environmental conditions.

18.

A freshly prepared sample contains $4.0\mu g$ of iodine-131. After 24 days, $0.5\mu g$ of iodine-131 remain. The best estimate of the half-life of iodine-131 is

A. 8 days.

B. 12 days.

C. 24 days.

D. 72 days.

19.

Which of the following causes the greatest number of ionizations as it passes through 1 cm of air? (The total energy of the ionizing radiation is the same.)

A. An alpha particle

B. A beta particle

C. A gamma-ray

D. An X-ray

20.

The graph below illustrates the variation with nucleon number (mass number) N of the binding energy per nucleon E of nuclei.

Which of the labelled nuclei is the most stable?