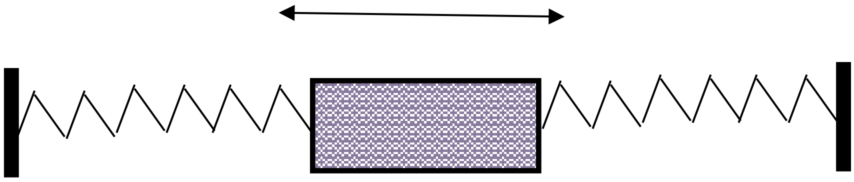
Rise and Fall

1 A mass M oscillates in simple harmonic motion between two fixed supports. Frictional effects can be ignored. The maximum acceleration of the mass is a_1.



The mass is replaced with a mass of 4 M **and** the amplitude of the oscillation is doubled. The maximum acceleration of the mass in the revised system is a_2.

Which is the correct statement?

A $a_2 = 4a_1$

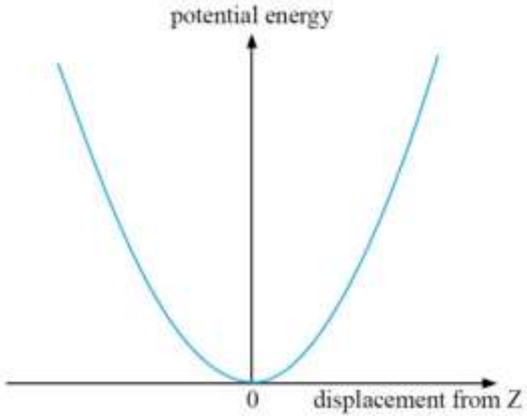
B $a_2 = 2a_1$

C $a_2 = a_1$

D $a_2 = \frac{1}{2} a_1$

Your answer ☐

2 The graph shows the way the potential energy of a body varies with its displacement from a point Z.



Which feature of the graph means that the force on the body is directed towards Z?

A The graph is approximately linear for large displacements.

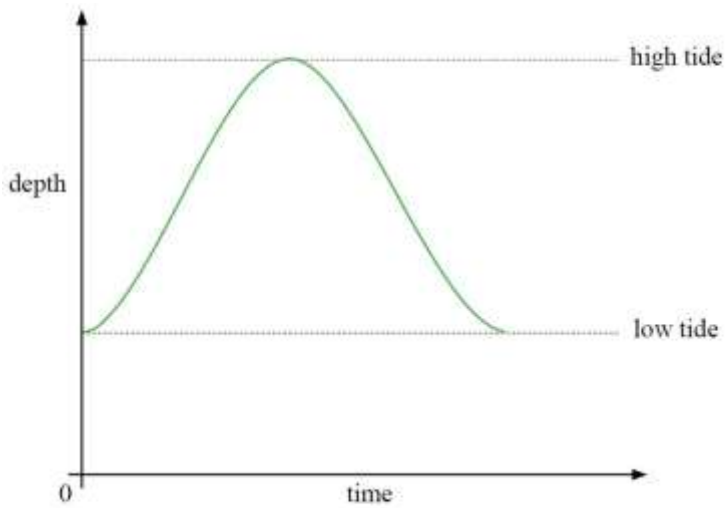
B The graph passes through the origin.

C The potential energy increases as the body moves further from Z.

D The value of potential energy, when not at Z, is always positive.

Your answer

3 The rise and fall of water in a harbour is simple harmonic. The depth varies between 1.0 m at low tide and 3.0 m at high tide. The time between successive low tides is twelve hours.



A boat which requires a minimum water depth of 1.5 m approaches the harbour at low tide.

How long must it wait before being able to enter the harbour.

A 1.0 hour

B 1.5 hours

C 2.0 hours

D 3.0 hours

Your answer

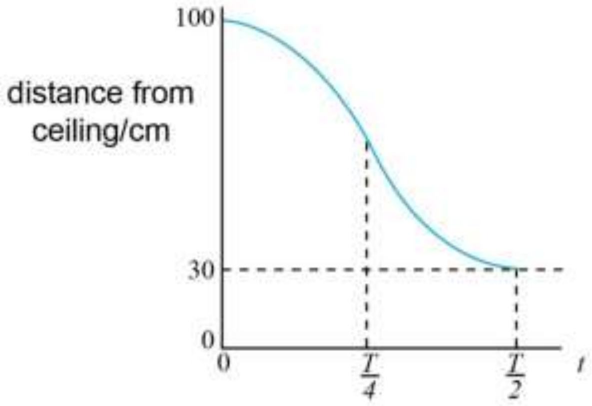
4 In which of the following lists are all three quantities constant when a particle moves in undamped simple harmonic motion?

A	acceleration	force	total energy
B	amplitude	force	kinetic energy
C	acceleration	period	kinetic energy
D	amplitude	period	total energy

Your answer

5 A mass hanging from a spring suspended from the ceiling is pulled down and released.

The mass then oscillates vertically with simple harmonic motion, period T.
The graph shows how the distance from the ceiling varies with time.



What can be deduced from this graph?

A The amplitude of the oscillation is 70 cm.

B The kinetic energy is maximum at $t = \frac{T}{2}$

C The restoring force on the mass increases between $t = 0$ and $t = \frac{T}{4}$

D The speed is maximum at $t = \frac{T}{4}$

Your answer ☐

6 A 2200 μF capacitor is discharged through a 2200 Ω resistor. To the nearest second, how long will it take for the charge to fall to half the original value?

A 1.0 s

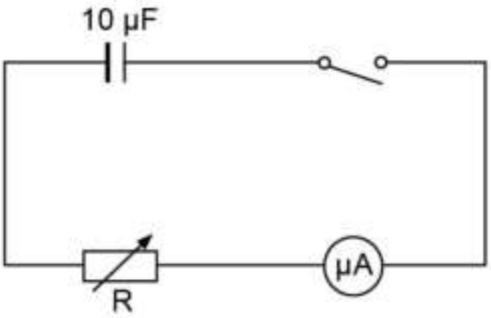
B 1.5 s

C 2.4 s

D 3.4 s

Your answer ☐

7 The circuit shown was used to discharge the 10 μF capacitor through the variable resistor R.



The current was kept at a constant 20 μA for 40 s by the continuous adjustment of R.

By how much did the potential difference across the capacitor fall during this time?

A 1.3×10^{-2} V

B 14 V

C 20 V

D 80 V

Your answer ☐

8 A capacitor is charged to a voltage V before being discharged through a small d.c. motor.

As the capacitor discharges, the motor raises a mass through a height h.

The experiment is repeated for several values of V.

A constant fraction of the capacitor energy is converted to gain of gravitational potential energy by the mass.

Which graph should give a straight line?

A h against V^2

B h against V

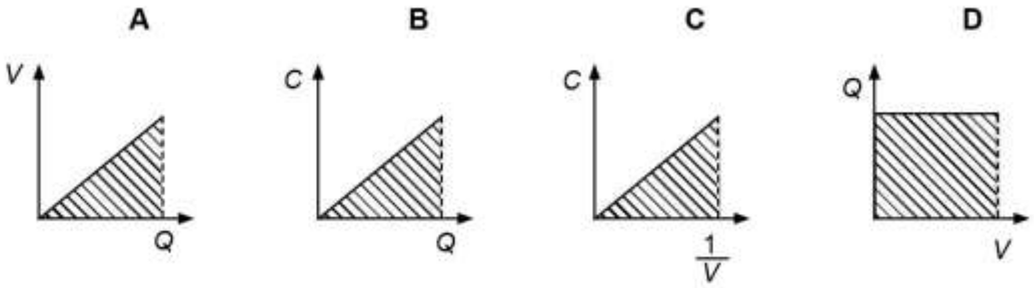
C h against $\sqrt{V}$

D h against $(\sqrt{V})^{-1}$

Your answer ☐

9 The energy stored in a capacitor of capacitance C, carrying charge Q, with potential difference V between its plates may be calculated from the area under the appropriate graph.

Which of the following graphs shows the correct relationship between the pair of quantities from C, Q and V, and in addition shows a shaded area which corresponds to the energy stored in the capacitor?



Your answer

10 When charging a capacitor through a resistor of resistance R, the current at time t is given by the equation $I = I_o e^{-\frac{t}{RC}}$ where I_o is the current as the timer is started.

Which of the following is the correct equation for the potential difference *V* across the capacitor at time *t*, where V_0 is the potential difference as the timer is started.

A $V = V_o e^{-\frac{t}{RC}}$

B $V = V_o\left(1 - e^{-\frac{t}{RC}}\right)$

C $V = R \times I_o e^{-\frac{t}{RC}}$

D $V = ln V_o - \frac{t}{RC}$

Your answer

11 The flashgun on a camera is activated when a capacitor discharges its energy over a very short period of time.

The capacitor in a particular camera is rated at 185 μF and is charged to 200V.

The capacitor discharges during the flash duration of 10 ms.

What is the mean power of the flash?

A 37 W

B 185 W

C 370 W

D 740 W

Your answer ☐

12 The potential difference *V* across a capacitor, of capacitance *C,* at a time *t* , while being discharged through a resistor of resistance *R,* is given by the formula

$$V = V_o e^{-\frac{t}{RC}}$$

Which of the following graphs will give a straight line, through the origin, with gradient $-\frac{1}{RC}$?

A $\ln(V/V_o)$ against *t*

B ln *V* against ln V_o

C ln *V* against ln *t*

D ln *V* against *t*

Your answer ☐

13 A source initially contains N_o nuclei of a radioactive nuclide.

How many of these nuclei have decayed after a time interval of three half-lives?

A $\frac{N_o}{8}$

B $\frac{N_o}{3}$

C $\frac{2N_o}{3}$

D $\frac{7N_o}{8}$

Your answer ☐

14 In a cancer therapy unit, patients are given treatment from a certain radioactive source. This source has a half-life of 4 years. A particular treatment requires 10 minutes of irradiation when the source is first used.

How much time is required for an equivalent treatment, using the same source, 2 years later?

A 7 minutes

B 10 minutes

C 14 minutes

D 20 minutes

Your answer ☐

15 Source A is a radioisotope with a half-life of 2 hours. Source B is a radioisotope with a half-life of 4 hours.

The initial activity of source A is twice that of source B.

How long will pass before the activity of source B is twice that of source A.

A 4 hours

B 6 hours

C 8 hours

D 12 hours

Your answer

16 Which of the following are the appropriate units for angular velocity, ω?

A s^{-1}

B $m\ s^{-1}$

C $kg\ m\ s^{-1}$

D $rad\ m^{-1}\ s^{-1}$

Your answer

17 A satellite orbits the Earth in a circular orbit of at an altitude of 2.3×10^{6} m above the ground.

For the Earth, $GM = 4.0 \times 10^{14}$ N m^2 kg^{-1} and $r = 6.4 \times 10^{6}$ m.

What is the angular velocity ω of the satellite?

A 6.1×10^{-7} rad s^{-1}

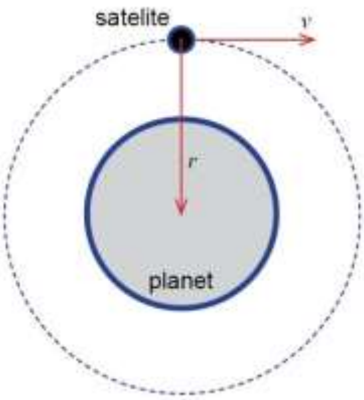
B 3.3×10^{-5} rad s^{-1}

C 7.8×10^{-4} rad s^{-1}

D 5.7×10^{-3} rad s^{-1}

Your answer

18 A satellite of mass *m* moves in a circular orbit at a speed *v* and a distance *r* from the centre of a planet of mass *M*.



Which expression gives the total energy of the satellite?

A $m\left(\frac{v^2}{r} - \frac{GM}{r}\right)$

B $m\left(\frac{v^2}{2} - \frac{GM}{r}\right)$

C $m\left(\frac{v^2}{r} + \frac{GM}{r}\right)$

D $m\left(\frac{v^2}{2} + \frac{GM}{r}\right)$

Your answer

19 If the Sun takes 250 million years to complete one orbit around the centre of the milky way, what is the angular velocity of the Sun?

A 8×10^{-16} rad s^{-1}

B 3×10^{-13} rad s^{-1}

C 3×10^{-12} rad s^{-1}

D 5×10^{16} rad s^{-1}

Your answer

20 What is the centripetal acceleration of a bike travelling at a speed of 12 m s^{-1} around a track of radius 50m?

A 0.24 m s^{-2}

B 2.9 m s^{-2}

C 4.5 m s^{-2}

D 7200 m s^{-2}

Your answer ☐

21 Two point masses m_1 and m_2 are a distance r apart.

What is the magnitude of the gravitational field strength caused by m_1 at m_2?

A $\dfrac{Gm_1m_2}{r}$

B $\dfrac{Gm_1m_2}{r^2}$

C $\dfrac{Gm_1}{r^2}$

D $\dfrac{Gm_2}{r^2}$

Your answer ☐

22 A communications satellite which takes 24 hours to orbit the Earth is replaced by a new satellite which has twice the mass of the old one.

The new satellite also has an orbit time of 24 hours.

What is the value of $\frac{radius\ of\ orbit\ of\ new\ satellite}{radius\ of\ orbit\ of\ old\ satellite}$?

A $\frac{1}{2}$

B $\frac{1}{1}$

C $\frac{\sqrt{2}}{1}$

D $\frac{2}{1}$

Your answer ☐

23 The ratio of masses $M_{\text{Earth}} / M_{\text{Mars}} \approx 10$ and the ratio of radii $R_{\text{Earth}} / R_{\text{Mars}} \approx 2$.

What is the best estimate of the ratio of gravitational fields at the surface of the two bodies $g_{\text{Earth}} / g_{\text{Mars}}$?

A 1

B 3

C 4

D 5

Your answer ☐

24 The ratio of masses $M_{\text{Earth}} / M_{\text{Mars}} \approx 10$ and the ratio of radii $R_{\text{Earth}} / R_{\text{Mars}} \approx 2$.

What is the best estimate of the ratio of gravitational potentials at the surface of the two bodies $V_{\text{Earth}} / V_{\text{Mars}}$?

A 1

B 3

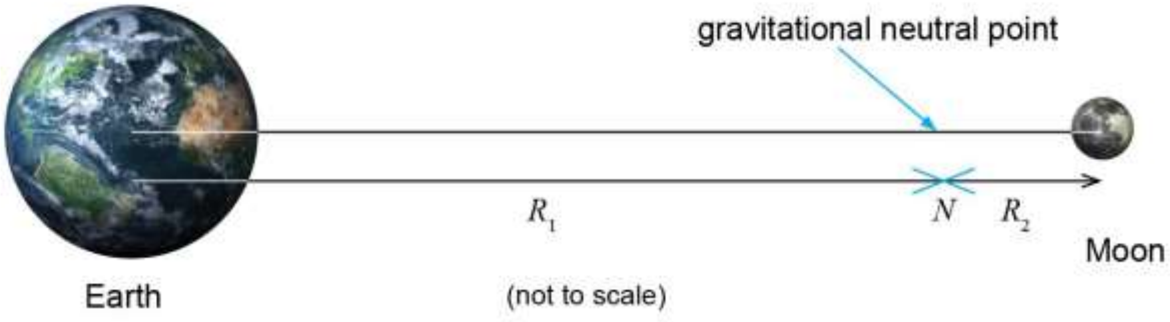
C 4

D 5

Your answer ☐

25 The gravitational neutral point N between the Earth and the Moon is the position where g_{total} for the two bodies is zero.

N is a distance R_1 from centre of the Earth and R_2 from centre of the Moon.



Which of the following statements is/are true?

1 The ratio $R_1 / R_2 = \sqrt{(M_{Earth} / M_{Moon})}$

2 At N two gravitational attractions act on a body but they are equal and opposite

3 At N, $\frac{\Delta V_{gravity}}{\Delta x} = 0$

A 1, 2 and 3 are correct

B Only 1 and 2 are correct

C Only 2 and 3 are correct

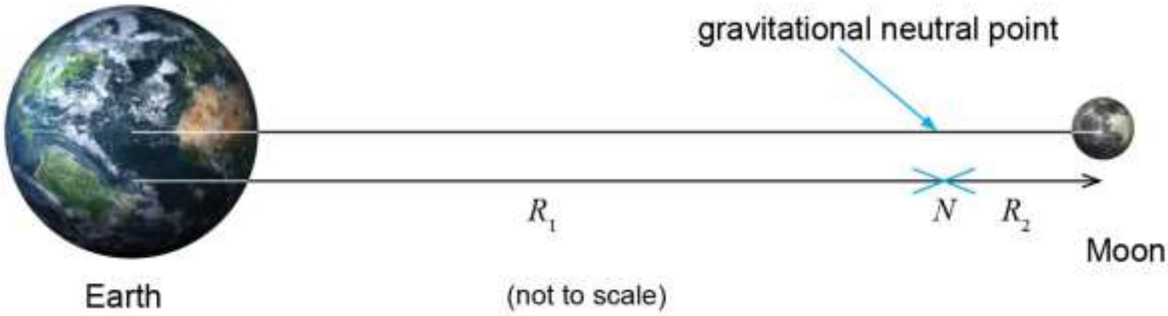
D Only 1 is correct

Your answer

26 The gravitational neutral point N between the Earth and the Moon is the position where g_{total} for the two bodies is zero.

N is a distance R_1 from centre of the Earth and R_2 from centre of the Moon.

The ratio of masses M_{Earth} / M_{Moon} ≈ 80 .



What is the correct value of the ratio R_1/R_2

A $1/\sqrt{80}$

B $\sqrt{80}$

C 80

D 80^2

Your answer

27 The acceleration of free fall on the surface of the Earth is about six times its value on the surface of the Moon.

The mean density of the Earth is about $\frac{5}{3}$ times the mean density of the Moon.

Using this data, what is the best value for the ratio of the radius of the Earth to the radius of the Moon?

A 1.9

B 3.2

C 3.6

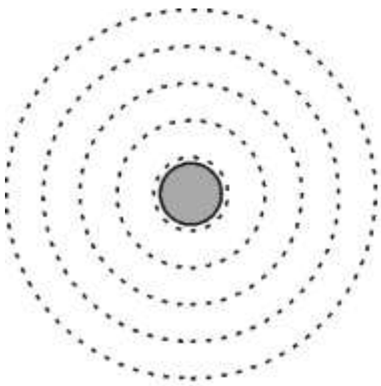
D 10

Your answer

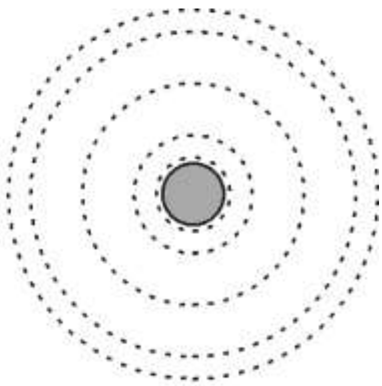
28 The diagrams below show four possible diagrams of the equipotentials near an isolated star.

In each diagram, the difference in gravitational potentials between adjacent equipotentials is the same.

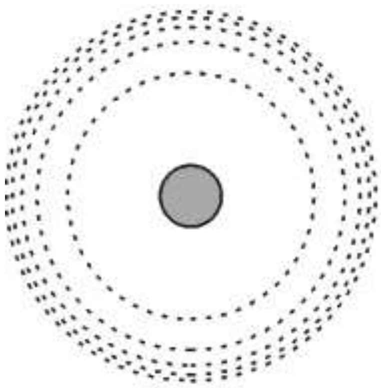
Which is correct?



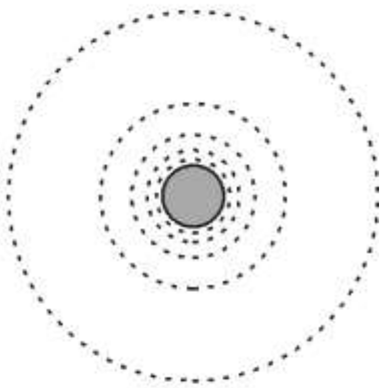
A



B



C



D

Your answer

29 When light from a star is passed through a diffraction grating it forms a spectrum.

Which of the following statements is/are correct?

1 The sun creates a continuous spectrum of visible light.

2 Visible light received from the sun has dark lines across its spectrum which correspond to the absorption of certain wavelengths by atoms in the Earth's atmosphere.

3 The photons in the emission spectrum are formed when electrons are moved from a lower energy level to a higher energy level within the atom.

A 1, 2 and 3 are correct

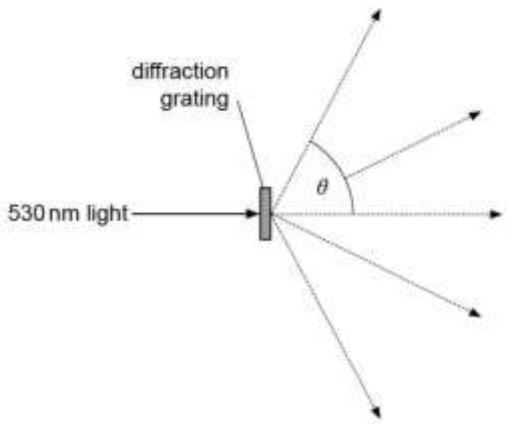
B Only 1 and 2 are correct

C Only 2 and 3 are correct

D Only 1 is correct

Your answer

30 A diffraction grating which has 830 lines mm^{-1} is illuminated with light of wavelength 530 nm.



What is the angle θ of the second-order diffraction maximum shown in the diagram expressed to two significant figures?

A 0.46 rad

B 1.1 rad

C 26 rad

D 62 rad

Your answer

31 A diffraction grating is ruled with 600 lines per mm.

When monochromatic light falls normally on the grating, the first-order diffracted beams are observed on the far side of the grating, each making an angle of 15° with the normal to the grating.

What is the frequency of the light?

A 1.2×10^{13} Hz

B 4.7×10^{13} Hz

C 3.6×10^{14} Hz

D 7.0×10^{14} Hz

Your answer

32 Which of the following observations support the origin of the Universe in a 'hot big bang'?

1 Cosmological redshift as shown by Hubble's Law

2 Cosmic microwave background radiation comes from all directions in space

3 Cosmic radiation detected contains neutrinos from distant supernovae

A 1, 2 and 3 are correct

B Only 1 and 2 are correct

C Only 2 and 3 are correct

D Only 1 is correct

Your answer

33 Which of the following observations demonstrate Doppler shift.

1 The sound of a train approaching an observer at high speed will be at a higher frequency than the sound of the train travelling away from the observer.

2 The frequency of the wave remains constant, but the wavelength observed is either reduced or extended depending on whether the object is travelling towards or away from the observer.

3 Light emitted from an object travelling at high speed relative to an observer will appear to travel at a speed greater than the speed of light.

A 1, 2 and 3 are correct

B Only 1 and 2 are correct

C Only 2 and 3 are correct

D Only 1 is correct

Your answer

34 Radio waves emitted by a particular pulsar are expected to have a frequency of 500 MHz. The actual frequency of the radio waves received is 400 Hz less. How fast is this pulsar moving relative to the observer?

A 240 ms^{-1}

B 670 ms^{-1}

C 3.8×10^5 ms^{-1}

D 2.4×10^8 ms^{-1}

Your answer

35 A diffraction grating is lit by a parallel beam of light from a gas discharge tube which emits monochromatic light.
Which of the following will increase the spacing between the bright points in the interference pattern produced on a screen at distance *d* from the grating?

1 Using a diffraction grating with fewer lines per mm

2 Increasing the potential difference applied to the discharge tube

3 Increase distance *d*.

A 1, 2 and 3 are correct

B Only 1 and 2 are correct

C Only 2 and 3 are correct

D Only 3 is correct

Your answer ☐

36 The distance from the surface of the earth to an orbiting satellite is determined by radar.
The return pulse is received 40 ms after the transmission of the outgoing pulse.
What is the distance of the satellite above the earth's surface?

A 3000 km

B 6000 km

C 12000 km

D 30000 km

Your answer

37 The velocity of blood in an artery can be determined using the Doppler effect with ultrasound.
Blood in an artery is moving directly towards a piezoelectric transducer, which emits ultrasound at a frequency of 7.5 MHz.
The blood is flowing at 7.5 ms^{-1}.
If the velocity of ultrasound in blood is 1600 ms^{-1}, what is the frequency of the signal which returns to the transducer?

A 7.43 MHz

B 7.47 MHz

C 7.53 MHz

D 7.57 MHz

Your answer

38 Early estimates of the Hubble constant were as high as 90 km s^{-1} Mpc^{-1}. Given that 1Mpc is 3.1 x 10^{22} m, which is the best answer for the age of the universe using these values?

A 1.1 x 10^{10} years

B 1.4 x 10^{10} years

C 4.0 x 10^{12} years

D 1.4 x 10^{13} years

Your answer [ ]

39 The temperature of a body at 100°C is increased by $\Delta\theta$ as measured on the Celsius scale.

How is this temperature change expressed on the Kelvin scale?

A $\Delta\theta$

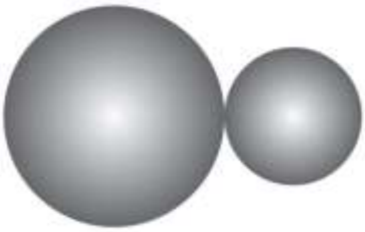
B $\Delta\theta + 273$

C $\Delta\theta - 273$

D $\Delta\theta + 373$

Your answer ☐

40 Two metal spheres of different radii are in continuous thermal contact in a vacuum as shown.



Which statement **must** be correct?

A Each sphere has the same internal energy.

B There is no net transfer of thermal energy between the spheres.

C Both spheres radiate electromagnetic energy at the same rate.

D The larger sphere has a greater mean internal energy per atom than the smaller sphere.

Your answer ☐

41 A metal mass of 100 g is heated up in a Bunsen flame to 600 °C and then dropped into 0.4 kg of water. The temperature of the water rises from 20 °C to 40 °C. The system is completely thermally isolated.

What is the value of the ratio $\frac{Specific\ heat\ capacity\ of\ metal}{Specific\ heat\ capacity\ of\ water}$?

A $\frac{2}{15}$

B $\frac{1}{7}$

C $\frac{4}{15}$

D $\frac{7}{1}$

Your answer ☐

42 The temperature of water entering a heater is 12°C. The rate of flow of water through the heater is 3.6×10^2 cm^3 min^{-1} and the output temperature of the water is 20°C.

What is the power of the heater?

(Density of water = 1000 kg m^{-3}, specific heat capacity of water 4200 J kg^{-1} K^{-1})

A 0.20 kW

B 0.50 kW

C 12 kW

D 20 kW

Your answer ☐

43 Cooling water enters the heat exchanger in the turbine hall of a nuclear power station at 6°C and leaves at 14°C.

The specific heat capacity of water 4200 J kg^{-1} K^{-1}.

If the rate of heat removal by the water is 6.72 x 10^9 J per minute, what is the rate of water flow?

A $\dfrac{6.72 \times 10^9}{4200 \times 8}$ kg s^{-1}

B $\dfrac{6.72 \times 10^9 \times 60}{4200 \times 8}$ kg s^{-1}

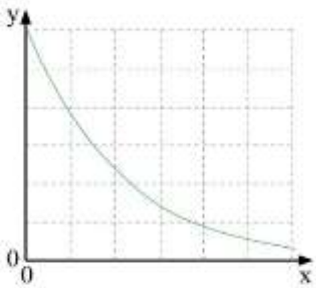
C $\dfrac{6.72 \times 10^9}{4200 \times 8 \times 60}$ kg s^{-1}

D $\dfrac{4200 \times 8 \times 60}{6.72 \times 10^9}$ kg s^{-1}

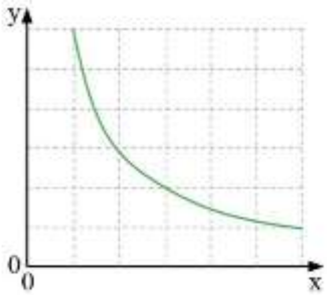
Your answer [ ]

44 The graphs **A – D** represent different relationships between variables in A level Physics. The dotted lines mark out equal intervals along the *x*- and *y*-axes.
Which graph best represents the relationship between the variables *x* and *y* where:
y is the pressure of a fixed mass of gas in a rigid container
x is the temperature of the gas

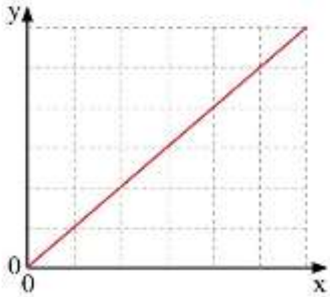
A



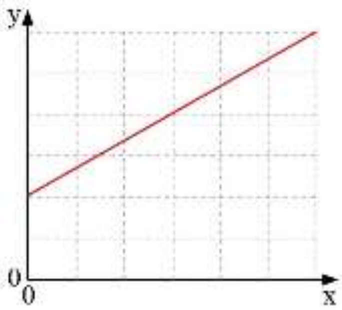
B



C



D



Your answer [ ]

45 What is the approximate number of atoms in one cubic metre of an ideal gas at a temperature of 27°C and pressure of 1×10^5 Pa?

A 1×10^{21}

B 1×10^{22}

C 6×10^{23}

D 2×10^{25}

Your answer

46 Here are some data about a volume of an ideal gas:

volume = 0.30×10^{-3} m^3

pressure = 0.30 MPa

temperature = 30˚ C

What is the number of particles in the volume of gas?

A 3.0×10^{19}

B 2.2×10^{22}

C 3.0×10^{23}

D 2.2×10^{25}

Your answer

47 The temperature of a fixed volume of an ideal gas is raised from 300 K to 330 K.

Which of the following statements about the gas is/are true?

1 The mean energy of the particles of the gas increases by 10%.

2 The mean square velocity of the particles of the gas increases by 10%.

3 The number of collisions per second with the walls of the container increases by 10%.

A 1, 2, 3 are correct

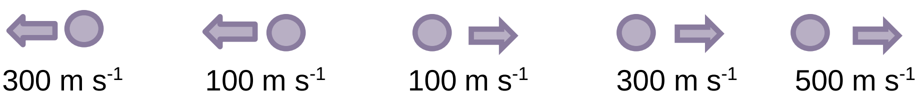
B Only 1 and 2 are correct

C Only 2 and 3 are correct

D Only 1 is correct

Your answer

48 Five molecules are moving with the speeds and directions shown.



What is the root mean square (r.m.s,) speed of these molecules?

A 100 m s^{-1}

B 224 m s^{-1}

C 300 m s^{-1}

D 500 m s^{-1}

Your answer

49 The pressure p of a gas occupying a volume V and containing N molecules of gas of mass m and mean square speed $\bar{c^2}$ is given by

$$p = \frac{1}{3}\frac{Nm}{V}\bar{c^2}.$$

The density of argon at a pressure of 1.00×10^5 Pa and at a temperature of 300 K is 1.60 kg m^{-3}.
What is the root mean square (r.m.s.) speed of argon molecules at this temperature?

A 216 m s^{-1}

B 250 m s^{-1}

C 306 m s^{-1}

D 433 m s^{-1}

Your answer

50 An airgun pellet, mass m and specific heat capacity c, hits a steel plate at speed v. During the impact, 50% of the pellet's kinetic energy is converted to thermal energy in the pellet.

What is the rise in temperature of the pellet?

A $\frac{v^2}{2c}$

B $\frac{v^2}{4c}$

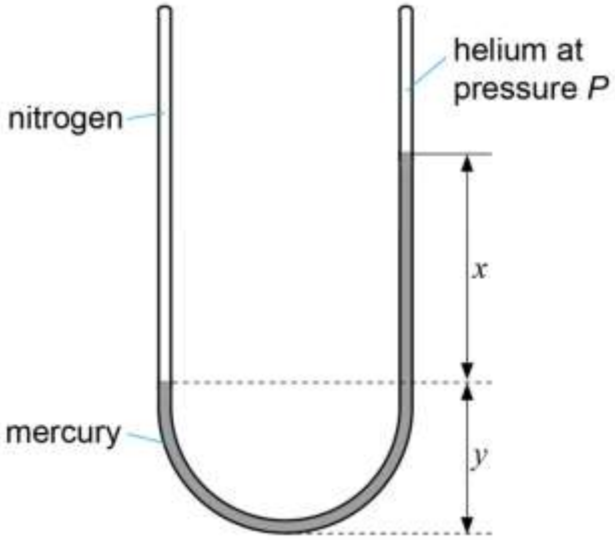
C $\frac{mv^2}{2c}$

D $\frac{mv^2}{4c}$

Your answer

51 A sealed U-tube contains nitrogen in one arm, and helium at pressure *p* in the other arm.

The gases are separated by mercury of density *ρ* , with dimensions *x* and *y* as shown on the diagram.



What is the pressure of the nitrogen?

A p

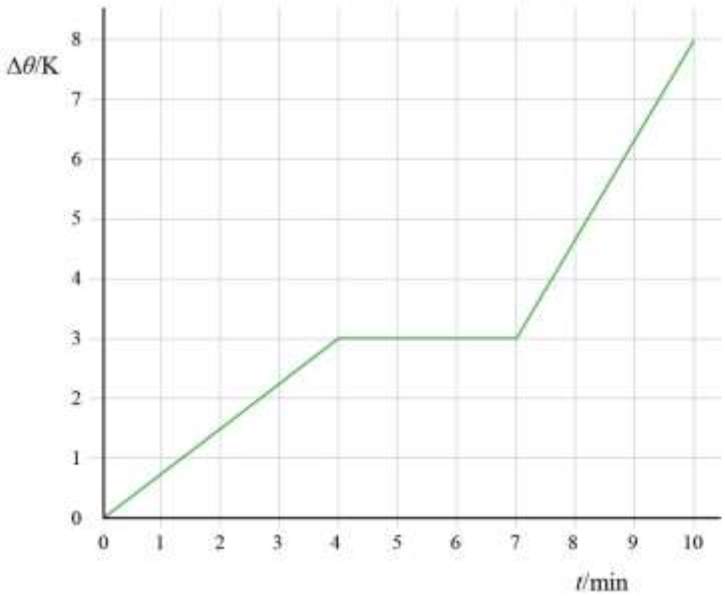
B $x\rho g$

C $p - x\rho g$

D $p + x\rho g$

Your answer

52 The graph shows the variation of temperature change $\Delta\theta$ with time t for 1 kg of a substance initially solid at room temperature. The substance is heated at a uniform rate of 2000 J min^{-1}.



What can be deduced from this graph?

A After 4 min of heating, the substance is all liquid.

B After 10 min of heating the substance is all gaseous.

C The specific heat capacity of the substance is greater when liquid than when solid.

D The specific latent heat of fusion of the substance is 6000 J kg^{-1}

Your answer

53 A plastic bottle containing a litre of water at 20°C is placed inside a freezer, whose temperature is maintained at -18°C.

The plastic bottle limits the transfer of energy to a mean value of 800 joule per minute for two hours and has negligible specific heat capacity.

For water, the specific heat capacity is 4200 J $kg^{-1}K^{-1}$ and specific latent heat of fusion 3.3×10^4 J kg^{-1}.

What is the temperature of the water at the end of the two hours?

A 0°C

B -0.36 °C

C -3.0°C

D -18 °C

Your answer

54 In a heating experiment, it was noted that the temperature of a liquid in a beaker rose at 4.0 K per minute. Immediately after the 4.0 K/min measurement was made, the water began to boil, and it was observed that, 40 minutes later, it had boiled away. For this liquid what is the numerical ratio of

$$\frac{specific\ heat\ capacity}{specific\ latent\ heat\ of\ vaporisation}$$

A $\frac{1}{10}$

B $\frac{1}{40}$

C $\frac{1}{160}$

D $\frac{1}{640}$

Your answer

55 Two stars have identical luminosity but differing surface temperatures. Star A has a surface temperature of 4000 °C whilst star B has a surface temperature of 5000 °C.

Star B has a radius of 5.0×10^5 m.

What is the radius of star A?

A 7.8×10^5 m

B 6.3×10^5 m

C 4.0×10^5 m

D 3.2×10^5 m

Your answer

56 Which of the following sequences is correct for the distances to be in descending order of magnitude?

A astronomical unit / light-year / parsec

B astronomical unit/ parsec / light-year

C parsec / light-year / astronomical unit

D light-year / astronomical unit / parsec

Your answer

57 What is the distance in light-years from the Earth to a star that makes a parallax angle of 2.0 arcseconds?

A 0.15 light-year

B 0.63 light-year

C 1.6 light-year

D 6.5 light-year

Your answer ☐