1. The best estimate for the time it takes light to cross the nucleus of the hydrogen atom is

A. $10^{-23}$ s.  
B. $10^{-20}$ s.  
C. $10^{-15}$ s.  
D. $10^{-7}$ s.

$t = \frac{\text{diameter of a nucleus}}{c} = 10^{-15}/3 \times 10^8 \approx 10^{-23}$

2. The length of each side of a sugar cube is measured as 10 mm with an uncertainty of ± 2 mm. Which of the following is the absolute uncertainty in the volume of the sugar cube?

A. ± 6 mm$^3$  
B. ± 8 mm$^3$  
C. ± 400 mm$^3$  
D. ± 600 mm$^3$

$\frac{\Delta V}{V} = \frac{\Delta a}{a} + \frac{\Delta a}{a} + \frac{\Delta a}{a} = 3 \frac{\Delta a}{a}$

$\Delta V = 3a^2 \Delta a = 600 \text{ cm}^3$
3. The time taken for a stone dropped from rest to fall vertically through 16 m is 2.0 s. Based on these measurements, what is the best estimate for the acceleration of free fall?

A. 4.0ms\(^{-2}\)  
B. 8.0ms\(^{-2}\)  
C. 9.8ms\(^{-2}\)  
D. 10ms\(^{-2}\)

\[ y = \frac{g}{2} t^2 \quad 16 = \frac{g}{2} 4 \quad g = 8 \text{ ms}^{-2} \]
4. A wooden block is sliding down an inclined plane at constant speed. The magnitude of the frictional force between the block and the plane is equal to

A. zero.

B. the magnitude of the weight of the block.

C. the magnitude of the component of weight of the block parallel to the plane. **C**

D. the magnitude of the component of the normal reaction parallel to the plane.

Object is in **translational equilibrium** if \( \vec{F}_{\text{net}} = 0, \ a = 0 \) velocity is const.
5. Which of the following is a correct statement of Newton’s second law of motion?

A. A force acting on a body is proportional to the mass of the body.

B. The rate of change of momentum of a body is equal to the net external force acting on the body.  \[ \boxed{B} \]

C. The momentum of a body is proportional to the net external force acting on the body.

D. A force acting on a body is proportional to the acceleration of the body.

\[ \text{Newton’s second law:} \quad F = \frac{\Delta p}{\Delta t} \]
6. A ball of weight $W$ is travelling horizontally towards a vertical wall. It strikes the wall and rebounds horizontally. The change in the magnitude of the momentum of the ball is $\Delta p$. Which of the following is the magnitude of the impulse that the ball imparts to the wall?

A. $W + \Delta p$
B. $W - \Delta p$
C. $W$
D. $\Delta p$

D

F $\Delta t = \Delta p$

- Impulse $F \Delta t$ imparted by the wall will change momentum of the ball by $\Delta p$
- by Newton’s third law ball exerts the force on the wall equal in magnitude but opposite in the direction
- at the time of interaction is the same, impulse imparted on the ball by the wall is the same in magnitude but opposite in direction as impulse imparted on the wall by the ball, and therefore change in momenta
- the only thing is that the wall is huuuuge, so change in velocity is $\approx 0$
7. Two objects undergo an inelastic collision. Which of the following is correct in respect of both the conservation of momentum and the conservation of total energy of the system?

<table>
<thead>
<tr>
<th>Momentum</th>
<th>Total energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. conserved</td>
<td>not conserved</td>
</tr>
</tbody>
</table>
| B. conserved     | conserved    | B
| C. not conserved | not conserved|
| D. not conserved | conserved    |
8. A particle P is moving anti-clockwise with constant speed in a horizontal circle. Which diagram correctly shows the direction of the velocity \( v \) and acceleration \( a \) of the particle P in the position shown?

C
9. Two objects are in thermal contact with each other. Which of the following will determine the direction of the transfer of thermal energy between the bodies?

A. The mass of each body
B. The area of contact between the bodies
C. The specific heat capacity of each body
D. The temperature of each body

**D**

*Heat* is the *thermal energy* that flows/is transferred from one body or system of higher temperature to another of lower temperature.

*Thermal equilibrium* occurs when all parts of the system are at the same temperature. There is no exchange of thermal energy/please do not mention heat. (This is how a thermometer works)
10. The mole is defined as

A. 1/12 the mass of an atom of the isotope carbon-12.
B. the amount of a substance that contains as many elementary entities as the number of atoms in 12 g of the isotope carbon-12.  
C. the mass of one atom of the isotope carbon-12.
D. the amount of a substance that contains as many nuclei as the number of nuclei in 12 g of the isotope carbon-12.

Avogadro’s number:
Number of constituent particles
(atoms/molecules) per mole of a given substance is $6.022 \times 10^{23} \text{ mol}^{-1}$
11. A gas is contained in a cylinder by a piston.

The gas is compressed rapidly by moving the piston in the direction shown. The best explanation for the resulting increase in temperature of the gas is that the molecules of the gas gain kinetic energy

A. from the moving piston.
B. by colliding more frequently with each other.
C. by being pushed closer together.
D. by colliding more frequently with the walls of the cylinder.

A
12. The graph shows how the velocity $v$ of an object undergoing simple harmonic motion varies with time $t$ for one complete period of oscillation.

Which of the following sketch graphs best shows how the total energy $E$ of the object varies with $t$?

A. 

B. 

C. 

D. 

Total energy is sum of kinetic and potential energy and it is equal to the initial potential energy given to the system (either elastic or gravitational)
13. A force that varies sinusoidally is applied to a system that is lightly damped. Which of the following must be true of the force for resonance to occur?

A. It must always be in anti-phase with the oscillations of the system.

B. Its direction must always be in the direction of motion of the oscillations of the system.

C. Its frequency must be equal to the frequency of oscillation of the system.  

D. Its amplitude must be equal to the amplitude of oscillation of the system.

C

Natural frequency is the frequency an object will vibrate with after an external disturbance.

Resonance: The increase in amplitude of oscillation of a system exposed to a periodic driving force with a frequency equal to the natural frequency of the system.

If the frequency of a driving force matches the natural frequency of the system, this leads to a better absorption of energy by the system, resulting in large amplitude oscillations.
14. Which of the following is a value of wavelength that is found in the visible region of the electromagnetic spectrum?

A. \(4 \times 10^{-5} \text{ m}\)
B. \(4 \times 10^{-7} \text{ m}\)
C. \(4 \times 10^{-9} \text{ m}\)
D. \(4 \times 10^{-11} \text{ m}\)

B. \(400 \text{ nm}\)

15. Two waves meet at a point in space. Which of the following properties always add together?

A. Displacement
B. Amplitude
C. Speed
D. Frequency

A. Interference is the addition (superposition) of two or more waves overlapping that results in a new wave pattern.

Principle of superposition: When two or more waves overlap, the resultant displacement at any point and at any instant is the vector sum of the displacements of the individual waves at that point: \(y = y_1 + y_2\)
16. A point charge of magnitude 2.0 μ C is moved between two points X and Y. Point X is at a potential of + 6.0 V and point Y is at a potential of + 9.0 V. The gain in potential energy of the point charge is

A. 0.20 μ J.
B. 1.5 μ J.
C. 6.0 μ J.
D. 30 μ J.

\[ \Delta U = q\Delta V = 2.0 \times 10^{-6}(9.0 - 6.0) = 6.0 \mu J \]
17. A resistor of resistance 12 \( \Omega \) is connected in series with a cell of negligible internal resistance. The power dissipated in the resistor is \( P \). The resistor is replaced with a resistor of resistance 3.0 \( \Omega \). What is the power dissipated in this resistor?

A. 0.25 \( P \)
B. \( P \)
C. 2.0 \( P \)
D. 4.0 \( P \)

\[
P_1 = IV = \frac{V}{R} \quad V \rightarrow \quad P = \frac{V^2}{R} = \frac{V^2}{12}
\]

\[
P_2 = \frac{V^2}{R_2} = \frac{V^2}{3} = 4P_1
\]
18. The electromotive force (emf) of a cell is defined as

A. the power supplied by the cell per unit current from the cell.
B. the force that the cell provides to drive electrons round a circuit.
C. the energy supplied by the cell per unit current from the cell.
D. the potential difference across the terminals of the cell.

- **Electromotive force**, (E or EMF or ε) is the work done per unit charge in moving charge completely around the circuit.

  \[ \Delta V = \Delta U/q \]

  \[ 1V = \frac{1J}{1C} \]

- **Electromotive force**, (E or EMF or ε) is the power supplied to the circuit per unit current

  \[ P = IV \Rightarrow V = \frac{P}{I} \]
19. The weight of an object of mass 1 kg at the surface of Mars is about 4 N. The radius of Mars is about half the radius of Earth. Which of the following is the best estimate of the ratio below?

\[
\frac{\text{mass of Mars}}{\text{mass of Earth}}
\]

A. 0.1

B. 0.2

C. 5

D. 10

\[
\frac{\text{weight on Mars}}{\text{weight on Earth}} = \frac{4N}{10N} = \frac{G \frac{mM_{Mars}}{(R_{Mars})^2}}{G \frac{mM_{Earth}}{(R_{Earth})^2}} = \frac{M_{Mars}}{(0.5R_{Earth})^2}
\]

\[
0.4 = \frac{1}{0.25} \frac{M_{Mars}}{M_{Earth}} \rightarrow \frac{M_{Mars}}{M_{Earth}} = 0.1
\]
20. Three positive point charges of equal magnitude are held at the corners X, Y and Z of a right-angled triangle. The point P is at the midpoint of XY. Which of the arrows shows the direction of the electric field at point P?

The only electric field that survives at point P is the one due to charge at the right angle corner. The other two cancel each other out.
21. An electron travelling in the direction shown by the arrow X, enters a region of uniform magnetic field. It leaves the region of field in the direction shown by the arrow Y. The direction of the magnetic field is

A. in the direction of X.
B. into the plane of the paper.
C. in the opposite direction to X.
D. out of the plane of the paper.

**R-H-R 1:** The direction of the magnetic **force on a charge/current** is given by the right-hand rule 1

Outstretch fingers in the direction of \( \mathbf{v} \) (or current \( I \)).
Curl fingers as if rotating vector \( \mathbf{v} \) (or \( I \)) into vector \( \mathbf{B} \).

**Magnetic force** on a **positive** charge (or \( I \)) is in the direction of the thumb

**Magnetic force** on a **negative** charge points in opposite direction.
22. Emission and absorption spectra provide evidence for
   A. the nuclear model of the atom.
   B. natural radioactivity.
   C. the existence of isotopes.
   D. the existence of atomic energy levels.  

   \textbf{Continuous Spectrum} (without prism white light) • a spectrum having all wavelengths over a comparatively wide range • All possible frequencies of EM waves are present. • Generally, solids, liquids, or high pressured (dense) gases emit a continuous spectrum when heated.

   \textbf{Discrete/ Line spectrum - Evidence of electron energy levels} – Pattern of distinct lines of color, corresponding to particular wavelengths.

   • \textit{Emission Spectrum} • Set of frequencies of the electromagnetic waves emitted by atoms of a particular element.
     • A hot, low-density / low pressure gas (gas in the atomic state) produces an emission-line spectrum – energy only at specific $\lambda$.
   • \textit{Absorption Spectrum} • Pattern of dark lines against a continuous spectrum background that results from the absorption of selected frequencies by an atom or molecule.
     • An \textit{absorption spectrum} occurs when light passes through a cold, dilute gas and atoms in the gas absorb at characteristic frequencies; since the re-emitted light is unlikely to be emitted in the same direction as the absorbed photon, this gives rise to dark lines (absence of light) in the spectrum.
23. Which of the following is true in respect of both the Coulomb interaction and the strong interaction between nucleons in an atom?

Coulomb interaction exists between

A. protons only
B. both protons and neutrons
C. protons only
D. both protons and neutrons

Strong interaction exists between

A. neutrons only
B. neutrons only
C. both protons and neutrons
D. both protons and neutrons

C
24. Which of the following correctly identifies the three particles emitted in the decay of the nucleus $^{45}_{20}\text{Ca}$ into a nucleus of $^{45}_{21}\text{Sc}$?

A. $\alpha, \beta^-, \gamma$

B. $\beta^-, \gamma, \bar{\nu}$

C. $\alpha, \gamma, \bar{\nu}$

D. $\alpha, \beta^-, \bar{\nu}$

One more proton: beta decay

$$\begin{align*}
\frac{1}{0}\text{n} & \rightarrow \frac{1}{1}\text{p} + \frac{0}{-1}\text{e} (\beta^-) + \bar{\nu} \\
\gamma \text{ decay does not change the nucleus itself} & \text{ – only energy state the nucleus is at}
\end{align*}$$
25. The nuclear reaction

\[ ^{2}_{1}H + ^{3}_{1}H \rightarrow ^{4}_{2}He + ^{1}_{0}n \]

is an example of

A. nuclear fission.
B. radioactive decay.
C. nuclear fusion. **C**
D. artificial transmutation.

26. Degraded energy is energy that is

A. stored in the Earth’s atmosphere.
B. available from non-renewable energy sources.
C. converted into work in a cyclical process.
D. no longer available for the performance of useful work. **D**
27. Which of the following correctly describes both the role of the moderator and of the control rods in a nuclear reactor?

**Moderator**
- A. slows down the neutrons
- B. cools down the reactor
- C. cools down the reactor
- D. slows down the neutrons

**Control rods**
- A. maintain a constant rate of fission
- extract thermal energy
- maintain a constant rate of fission
- extract thermal energy

**Main energy transformations in a nuclear power station:** nuclear energy $\rightarrow$ thermal energy $\rightarrow$ mechanical energy $\rightarrow$ electrical energy

Three important components in the design of all nuclear reactors are **moderator**, **control rods** and **heat exchanger**.

- **Moderator** is a medium that **slows down** fast neutrons to make them suitable for reaction (water, graphite, heavy water).
- **Control rods** are movable rods that readily **absorb** neutrons. They can be introduced or removed from reaction chamber in order to control the rate of fission of **uranium** and **plutonium**. Made of chemical elements capable of absorbing many neutrons without fissioning themselves (cadmium, hafnium, boron, etc)
- **Heat exchanger** is used to seal off the place where nuclear reactions take place from the rest of the environment. In some nuclear power plants, the steam from the reactor goes through a heat exchanger to convert another loop of water to steam, which drives the turbine. The advantage to this design is that the radioactive water/steam never contacts the turbine.
28. Which of the following correctly shows the energy change in a photovoltaic cell and in a solar heating panel?

<table>
<thead>
<tr>
<th>Photovoltaic cell</th>
<th>Solar heating panel</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. solar → electrical</td>
<td>solar → thermal</td>
</tr>
<tr>
<td>B. electrical → thermal</td>
<td>solar → electrical</td>
</tr>
<tr>
<td>C. solar → electrical</td>
<td>electrical → thermal</td>
</tr>
<tr>
<td>D. electrical → thermal</td>
<td>solar → thermal</td>
</tr>
</tbody>
</table>

A
29. The albedo for the oceans is lower than that for glaciers. This is because, compared to ice, sea water

A. has a greater density.
B. has a greater specific heat capacity.
C. has a greater coefficient of volume expansion.
D. absorbs a greater amount of radiative power.  

\[ \alpha = \frac{\text{total (reflected) scattered power}}{\text{total incident power}} \]
30. Which of the following is most likely to reduce the enhanced greenhouse effect?

A. Replace the use of gas powered stations with oil powered stations
B. Replace coal-fired power stations with nuclear power stations  **B**
C. Increase the use of all non-renewable energy sources
D. Decrease the efficiency of power production
Physics
Standard level
Paper 1

Monday 10 May 2010 (afternoon)

45 minutes
1. The current in a resistor is measured as 2.00 A ± 0.02 A. Which of the following correctly identifies the absolute uncertainty and the percentage uncertainty in the current?

<table>
<thead>
<tr>
<th>Absolute uncertainty</th>
<th>Percentage uncertainty</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. ± 0.02 A</td>
<td>±1 %</td>
</tr>
<tr>
<td>B. ± 0.01 A</td>
<td>± 0.5 %</td>
</tr>
<tr>
<td>C. ± 0.02 A</td>
<td>± 0.01 %</td>
</tr>
<tr>
<td>D. ± 0.01 A</td>
<td>± 0.005 %</td>
</tr>
</tbody>
</table>

1. absolute uncertainty: \( \Delta I = \pm 0.02 A \)
2. percentage uncertainty: \( \frac{\Delta I}{I} \times 100\% = \pm 1\% \) (one sig. fig)
2. Which of the following lists only two vector quantities?
   A. mass, energy, work
   B. momentum, work, speed
   C. weight, force, acceleration
   D. momentum, energy, displacement  \[ \text{D} \]
3. Samantha walks along a horizontal path in the direction shown. The curved part of the path is a semi-circle.

The magnitude of her displacement from point P to point Q is approximately

A. 2 m.
B. 4 m.  \[2\times\text{radius} + 4m = 8m\]
C. 6 m.
D. 8 m.  D
4. Which of the following may be determined from a speed-time graph?

A. Displacement

B. Distance

C. Power

D. Force

\[ \text{B area below velocity vs time graph = displacement} \]
\[ \text{area below speed vs time graph = distance} \]
5. Stephen pushes two boxes P and Q, that stay in contact, along a rough table, with a force F of 30 N. Box P has a mass of 2.0 kg and box Q has a mass of 4.0 kg. Both boxes move with constant speed.

The resultant force on box Q is

A. 0 N.  
B. 5.0 N.  
C. 15 N.  
D. 30 N.  

A Object is in *translational equilibrium* if \( \vec{F}_{\text{net}} = 0, \quad \vec{a} = 0 \) velocity is const.
6. A ball moves along the inside of a horizontal semi-circular ring as shown. The diagram is a view from above.

at each position force is toward the center. Each of the forces can be decomposed into two components: one horizontal and one vertical. The vertical components will cancel out.

Which arrow represents the direction of the average force on the ball?
7. A ball is thrown vertically upwards and comes down again. Air resistance is negligible. Which of the following graphs shows how the gravitational potential energy $E_P$ varies with time $t$?

\[ E_P = mg\,y \]

D. looks exactly as the graph displacement $y$ vs. time
8. A pump extracts water from a well of depth $h$ at a constant rate of $R \text{ kg s}^{-1}$. What is the power required to raise the water?

A. $\frac{R}{gh}$

B. $Rgh$

C. $\frac{Rg}{h}$

D. $\frac{hg}{R}$

\[
\Delta m = R \frac{kg}{s} \quad P = \frac{\Delta mgh}{t} = Rgh
\]
9. A box that is at rest with respect to horizontal ground contains a fixed quantity of an ideal gas. The internal energy of the gas is \( U \) and its temperature is \( T \). The box is now made to move at constant speed with respect to the ground. Which of the following gives the change, if any, in the internal energy and the temperature of the gas after the box has been moving for some time?

<table>
<thead>
<tr>
<th>Internal energy</th>
<th>Temperature</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. no change</td>
<td>no change</td>
<td>A</td>
</tr>
<tr>
<td>B. no change</td>
<td>increase</td>
<td></td>
</tr>
<tr>
<td>C. increase</td>
<td>no change</td>
<td></td>
</tr>
<tr>
<td>D. increase</td>
<td>increase</td>
<td></td>
</tr>
</tbody>
</table>

yup: Internal energy doesn’t depend on potential energy but this is pretty stupid, because internal energy of anything doesn’t depend on gravitational potential energy, only on potential energy due to mutual interactions between constituent particles. And temperature is proportional to the average kinetic energy of constituent particles.
10. Object P has a mass \( m_P \) and specific heat capacity \( c_P \). Object Q has a mass \( m_Q \) and specific heat capacity \( c_Q \). The temperature of each object increases by the same amount. Which of the following gives the ratio

\[
\frac{\text{thermal energy transferred to object P}}{\text{thermal energy transferred to object Q}}
\]

A. \( \frac{m_P c_Q}{m_Q c_P} \)

B. \( \frac{m_P c_P}{m_Q c_Q} \)

C. \( \frac{m_Q c_Q}{m_P c_P} \)

D. \( \frac{m_Q c_P}{m_P c_Q} \)

\( Q = mc\Delta T \)
11. For two objects to be in thermal equilibrium they must
   A. be in contact with each other.
   B. radiate equal amounts of power.
   C. have the same thermal capacity.
   D. be at the same temperature.  

*Heat* is the *thermal energy* that flows/is transferred from one body or system of higher temperature to another of lower temperature.

*Thermal equilibrium* occurs when all parts of the system are at the same temperature. There is no exchange of thermal energy/please do not mention heat. (This is how a thermometer works)
12. The shock absorbers of a car, in good working condition, ensure that the vertical oscillations of the car are

A. undamped.
B. lightly damped.
C. moderately damped.
D. critically damped.

Critical/heavy damping: occurs if the resistive force is so big that the system returns to its equilibrium position without passing through it. The mass comes to rest at its equilibrium position without oscillating. The friction forces acting are such that they prevent oscillations.
13. The graphs show how the acceleration $a$ of four different particles varies with their displacement $x$. Which of the particles is executing simple harmonic motion?

Simple Harmonic Motion is periodic motion in which the acceleration/restoring force is proportional to and in opposite direction of the displacement.

$$a = -\omega^2 x \quad F = -m\omega^2 x$$

$\omega$ is angular frequency $= \frac{2\pi}{T}$
14. The diagram below is a snapshot of wave fronts of circular waves emitted by a point source S at the surface of water. The source vibrates at a frequency \( f = 10.0 \) Hz.

wavelength is the distance between two wavefronts (circles) \( \approx 1.5 \) cm

\[ v = \lambda f = 15 \text{ cm/s} \]

The speed of the wave front is

A. 0.15 cm s\(^{-1}\).

B. 1.5 cm s\(^{-1}\).

C. 15 cm s\(^{-1}\).  \( \boxed{C} \)

D. 30 cm s\(^{-1}\).
15. Two coherent point sources $S_1$ and $S_2$ emit spherical waves.

P: superposition of two crests
path difference
= the whole number of $\lambda$
constructive interference

Q: superposition of crest and trough
path difference
= the odd number of $\lambda/2$
destructive interference

Which of the following best describes the intensity of the waves at P and Q?

<table>
<thead>
<tr>
<th></th>
<th>P</th>
<th>Q</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>maximum</td>
<td>minimum</td>
</tr>
<tr>
<td>B</td>
<td>minimum</td>
<td>maximum</td>
</tr>
<tr>
<td>C</td>
<td>maximum</td>
<td>maximum</td>
</tr>
<tr>
<td>D</td>
<td>minimum</td>
<td>minimum</td>
</tr>
</tbody>
</table>
16. An alpha particle is accelerated through a potential difference of 10 kV. Its gain in kinetic energy is

A. 10 eV.

B. 20 eV.

C. 10 keV.

D. 20 keV.

\[ KE = \Delta U = q\Delta V = (2e)(10kV) = 20keV \]
17. A copper wire, of electric resistance $R$, has a length $L$ and a cross-section area $S$. Another copper wire has a length $2L$ and a cross-section area of $S/2$. Which of the following is the resistance of this wire?

A. $R/4$
B. $R/2$
C. $2R$
D. $4R$

\[
R = \rho \frac{L}{S}
\]

\[
R_{\text{new}} = \rho \frac{2L}{S/2} = 4 \rho \frac{L}{S}
\]

D
18. The circuit shows a light-dependent resistor (LDR) in series with a resistor and a cell. The emf of the cell is $\varepsilon$. The internal resistance of the cell is negligible.

A photoresistor or light-dependent resistor (LDR) or photocell is a light-controlled variable resistor. The resistance of a photoresistor decreases with increasing incident light intensity; in other words, it exhibits photoconductivity. A photoresistor can be applied in light-sensitive detector circuits, and light- and dark-activated switching circuits.

$\text{emf} = \text{potential drop across resistor} + \text{potential drop across LDR}$

$$\varepsilon = \frac{\varepsilon}{R + R_{LDR}} R + \frac{\varepsilon}{R + R_{LDR}} R_{LRD}$$

$$\varepsilon = \frac{\varepsilon}{1 + \frac{R_{LDR}}{R}} + \frac{\varepsilon}{\frac{R}{R_{LDR}} + 1}$$

If light increases $R_{LDR}$ decreases

When light shines on the LDR, the potential difference across the resistor will

A. stay the same.  \[\text{C}\]

B. decrease.

C. increase but always be less than $\varepsilon$.

D. increase and exceed $\varepsilon$.  

19. The radius of a charged spherical conductor is R. Which of the following graphs best shows how the magnitude of the electrical field strength \( E \) varies with distance \( r \) from the centre of the sphere?

Electric field inside charged or noncharged conductor in electrostatic equilibrium (no current) is zero. Outside falls of the same way as it would be from point charge \( \sim \frac{1}{r^2} \)
20. Which of the following gives the acceleration of an electron of electric charge e and mass m in a uniform electric field of strength E?

A. $E$

B. $Ee$

C. $\frac{Ee}{m}$

D. $\frac{m}{Ee}$

\[ a = \frac{F}{m} = \frac{eE}{m} \]
21. A particle, of mass \( m \) and charge \( q \), moves with velocity \( v \) perpendicularly to a magnetic field. The magnitude of the magnetic force acting on the particle at a particular point is \( F \). Which of the following gives the magnitude of the magnetic field strength at that point?

A. \[ \frac{F}{q} \]  
   magnetic force on moving charge :
   \[ F = qvB \sin \theta \]

B. \[ \frac{F}{m} \]

C. \[ \frac{F}{v} \]

D. \[ \frac{F}{qv} \]  
   D
22. Which of the following decay sequences would result in the daughter nucleus having the same proton number as the parent nucleus?

A. Alpha followed by gamma

B. Beta ($\beta^-$) followed by gamma

C. Alpha followed by beta ($\beta^-$) followed by beta ($\beta^-$)  

D. Beta ($\beta^-$) followed by gamma followed by gamma  

**C**

*Alpha decay:* nucleus ejects an $\alpha$ particle, the atomic number is decreased by two and the atomic mass is decreased by four • *charge is +2e*

*Beta decay:* nucleus spontaneously emits beta particle and an antineutrino

$\frac{1}{0}n \rightarrow \frac{1}{1}p + \frac{0}{-1}e (\beta^-) + \bar{\nu}$

alpha decay means two protons less  
2 beta minus decays means two protons more
23. The difference between the mass of a $^{12}_6$C nucleus and the sum of the masses of the individual nucleons is 0.1 u. Which of the following is approximately the binding energy of the nucleus?

A. 90 MeV

B. 90 MeV $c^{-2}$

C. 8 MeV

D. 8 MeV $c^{-2}$

**Binding Energy** is the work required to completely separate the nucleons of a nucleus/energy released when nucleons form a nucleus.

- Nuclear binding energy is actually energy that corresponds to mass defect
  1. **BE in MeV:** find mass defect in u and multiply it by 931.5 MeV
  2. **ME in J:** $BE = \delta c^2$ ($c = 3 \times 10^8$ m/s, $\delta =$ mass defect in kg)
24. The process by which a heavy nucleus splits into two lighter nuclei is known as
   A. fission.  [A]
   B. fusion.
   C. radioactive decay.
   D. artificial (induced) transmutation.
25. Which of the following correctly shows a renewable and a non-renewable source of energy?

<table>
<thead>
<tr>
<th>Renewable</th>
<th>Non-renewable</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. oil</td>
<td>geothermal</td>
</tr>
<tr>
<td>B. wind</td>
<td>biofuels</td>
</tr>
</tbody>
</table>
| C. ocean waves      | nuclear          | C
| D. natural gas     | coal             |
26. Critical mass refers to the amount of fissile material that
   A. will allow fission to be sustained.  
   B. is equivalent to 235 g of uranium.  
   C. will produce a growing chain reaction.  
   D. is the minimum mass necessary for fission to take place.
27. The annual variations of solar power incident per unit area at a particular point on the Earth’s surface is mainly due to the change in the

A. distance between the Earth and the Sun.

B. angle at which the solar rays hit the surface of the Earth.  

C. average albedo of the Earth.

D. average cloud cover of the Earth.
28. The water in a reservoir behind a dam drops from an initial height \( H_0 \) above a turbine to produce hydroelectricity. At time \( t = T, h = 0 \).

The graph shows the variation with time \( t \) of the height \( h \) of the water above the turbine.

Which of the following is a measure of the maximum theoretical electric power available?

A. \( H_0 \) and the slope of the graph
B. \( T \) and the slope of the graph
C. \( T \) and the area under the graph
D. \( H_0 \) and the area under the graph

\[ P = \frac{mgh}{t} \]
The energy stored in a lake at altitude is gravitational \( PE = mgh \).

\( h \) is the height difference between the outlet from the lake and the turbine. Since not all of the water in the lake is the same height, the **average height** is used (this is assuming the lake is rectangular in cross section).

The **rate of change** of the potential energy converted into kinetic energy is

\[
P = \frac{mgh}{t} = \frac{(\rho V)gh}{t} = \rho \frac{V}{t} gh = \rho \frac{Q}{t} gh
\]

\( \rho \) – density of the water

\( V \) – volume of the lake

\( Q \) is known as the volume flow rate (\( m^3/s \))
29. Each square metre of the Sun’s surface emits S joules per second. The radius of the Sun is $r$, and the Sun is at a mean distance $R$ from the Earth. Which of the following gives the solar power incident per unit area of the top layer of the Earth’s atmosphere?

A. $\left(\frac{r}{R}\right)^2 S$

B. $\left(\frac{r}{R}\right) S$

C. $\left(\frac{R}{r}\right) S$

D. $\left(\frac{R}{r}\right)^2 S$
30. The diagram shows a simple climate model for Earth. The temperature of the ground is $T_g$ and is assumed to radiate as a black body. The temperature of the atmosphere is $T_a$ and has an emissivity $\varepsilon$.

In the model, the intensity radiated from the ground equals the intensity radiated from the atmosphere towards the ground. What is the ratio $\frac{T_g}{T_a}$?

A. $\varepsilon^4$
B. $\varepsilon$
C. $\varepsilon^{\frac{1}{4}}$
D. 1

C
NOVEMBER 2010 PAPER one is handwritten and uploaded as
PAPER 1 NOV 2010 NOV 2011 May1 2012 - SOL
Physics
Standard level
Paper 1

Monday 8 November 2010 (afternoon)

45 minutes
1. Which of the following is equivalent to the joule?
   A. N m^2
   B. N m^{-2}
   C. kg m s^{-2}
   D. kg m^2 s^{-2}  \textbf{D}

   Any energy or work has the same units: Joules

   Easiest: \( W = Fd \)

   \[ J = kg \, m \, s^{-2} \]

2. An object falls for a time of 0.25 s. The acceleration of free fall is 9.81 m s^{-2}. The displacement is calculated. Which of the following gives the correct number of significant digits for the calculated value of the displacement of the object?
   A. 1
   B. 2 \textbf{B} 0.25 s 2 \text{ sig fig}
   C. 3
   D. 4 0.25 s \text{ smallest number of significant figures in multiplication or division}

   when adding or subtracting ... the smallest number of decimal places (precision)
3. A raindrop falling from rest at time \( t=0 \) reaches terminal velocity. Which graph best represents how the speed \( v \) varies with time \( t \)?

A. 

B. 

C. 

D. 

\[ v \]
\[ 0 \]
\[ t \]

\[ 0 \]

\[ v \]

\[ 0 \]

\[ t \]

\[ 0 \]

\[ v \]

\[ 0 \]

\[ t \]

\[ 0 \]

\[ v \]

\[ 0 \]

\[ t \]

B. Air resistance increases as the speed increases. Net force decreases and eventually becomes zero. Acceleration decreases and eventually is zero. Speed is constant then = terminal speed.
4. The graph shows how the displacement $d$ of an object varies with time $t$. The tangent to the curve at time $t_1$ is also shown.

Which of the following gives the speed of the object at point P?

A. the gradient at P
B. the shaded area
C. $\frac{1}{\text{gradient at } P}$
D. $\frac{d_1}{t_1}$

From the graph
\[\text{tangent} = \frac{d}{dt} \text{displacement} = \dot{v}\]
5. A ball falls vertically and bounces off the ground. Immediately before impact with the ground the speed of the ball is \( u \). Immediately after leaving the ground the speed is \( v \).

Which of the following expressions is the ratio of kinetic energy lost on collision to kinetic energy immediately before collision? 

\[
\text{Loss} = \frac{\frac{1}{2} m u^2 - \frac{1}{2} m v^2}{\frac{1}{2} m u^2} = 1 - \frac{v^2}{u^2}
\]

By the way: change = final – initial

\[\Delta \vec{p} = m \vec{v} - m \vec{u} = m \vec{v} + m \vec{u}\]

Directions!!!!!
6. A railway engine of mass \( m \) moves along a horizontal track with uniform speed \( v \). The total resistive force acting on the engine is \( F \).

Which of the following is the power of the engine?

A. \( \frac{F}{mv} \)

\( v \) is constant

B. \( Fv \)

\( a = 0 \quad F_{\text{net}} = 0 \)

forward force = resistive force

C. \( \frac{mv}{F} \)

\( P_{\text{engine}} = \text{forward force} \times v = Fv \)

D. \( \frac{v}{F} \)
7. A ball is tied to a string and rotated at a uniform speed in a vertical plane. The diagram shows the ball at its lowest position. Which arrow shows the direction of the net force acting on the ball?

There MUST BE a centripetal force forcing it to move in circle.
WHAT?
I know, I know
When we were talking about pendulum we took into account ONLY force responsible for tangential acceleration (to speed it up or slow it down)
Explanation: At this position tension force is greater than gravitational force resulting in net force pointing toward centre
8. A gas atom strikes a wall with speed $v$ at an angle $\theta$ to the normal to the wall. The atom rebounds at the same speed $v$ and angle $\theta$.

Which of the following gives the magnitude of the momentum change of the gas atom?

A. zero  
B. $2mv \sin \theta$  
C. $2mv$  
D. $2mv \cos \theta$  

D

$p_x = p \cos \theta$

will change direction into opposite so change in momentum in $x$ direction is final – initial

vertical components will cancel:

$\quad - \quad = \quad 0$

$2p \cos \theta$
9. A system consists of an ice cube placed in a cup of water. The system is thermally insulated from its surroundings. The water is originally at 20°C. Which graph best shows the variation of total internal energy $U$ of the system with time $t$?

A.  

System doesn’t exchange energy with surroundings – therefore energy remains constant. It is transformed from kinetic into potential and vice versa.
10. Thermal energy is added at a constant rate to a substance which is solid at time $t = 0$. The graph shows the variation with $t$ of the temperature $T$.

Which of the statements are correct?

I. The specific latent heat of fusion is greater than the specific latent heat of vaporization.

II. The specific heat capacity of the solid is less than the specific heat capacity of the liquid.

A. I only
B. I and II
C. II only
D. Neither I nor II

\[ c = \frac{Q}{m\Delta T} \]

\[ Q \sim t \quad \text{so gradient} \sim \frac{\Delta T}{Q} \sim \frac{1}{c} \]

\[ \therefore \text{greater gradient smaller } c \]

\[ \begin{align*}
\text{the mass is the same throughout the process, so during}\ &
\text{vaporization energy added @ constant rate is much}
\text{greater than during fusion (time is much greater)}
\end{align*} \]

\[ \therefore \text{it needs more energy for vaporization} \]

\[ \begin{align*}
as \ L = \frac{Q}{m} & \quad L_{\text{vaporization}} > L_{\text{fusion}}
\end{align*} \]
11. Which of the following is an assumption made in the kinetic model of ideal gases?

A. Molecules have zero mass.
B. Forces between molecules are attractive.
C. Collisions between molecules are elastic.
D. Molecules move at high speed.

**Assumptions of the kinetic model of an ideal gas.**

- Gases consist of tiny hard spheres/particles called atoms or molecules.
- The total number of molecules in any sample of a gas is extremely large.
- The molecules are in constant random motion.
- The range of the intermolecular forces is small compared to the average separation of the molecules.
- The size of the particles is relatively small compared with the distance between them.
- No forces act between particles except when they collide, and hence particles move in straight lines.
- Between collisions the molecules obey Newton’s Laws of motion.
- Collisions of short duration occur between molecules and the walls of the container and the collisions are perfectly elastic (no loss of kinetic energy).
Question 12 and Question 13 both refer to the following.
An object at the end of a spring oscillates vertically with simple harmonic motion. The graph shows the variation with time $t$ of the displacement $x$. The amplitude is $x_0$ and the period of oscillation is $T$.

12. Which of the following is the correct expression for the displacement $x$?

A. $-x_0 \cos \frac{2\pi}{T} t$

B. $x_0 \cos \frac{2\pi}{T} t$

C. $-x_0 \sin \frac{2\pi}{T} t$

D. $x_0 \sin \frac{2\pi}{T} t$

13. Which of the following is the correct expression for the maximum acceleration of the object?

A. $\frac{2\pi}{T} x_0$

B. $\frac{2\pi}{T^2} x_0$

C. $\omega = 2\pi f = \frac{2\pi}{T}$

D. $\frac{4\pi^2}{T^2} x_0$
14. One end of a horizontal string is fixed to a wall. A transverse pulse moves along the string as shown.

Which of the following statements are correct for the reflected pulse compared to the forward pulse?

I. It moves more slowly.
II. It has less energy.
III. It is inverted.

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

Reflected wave from the fixed end is:
- inverted
- the same speed (the same medium, and speed depends on medium ONLY)
- amplitude smaller $E \sim A^2$, and some of the energy is transferred to the wall
- by the way, reflected wave from the free end is not inverted
15. Monochromatic light travels from air into water. Which of the following describes the changes in wavelength and speed?

<table>
<thead>
<tr>
<th>Wavelength</th>
<th>Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.</td>
<td>increases decreases</td>
</tr>
<tr>
<td>B.</td>
<td>increases increases</td>
</tr>
<tr>
<td>C.</td>
<td>decreases increases</td>
</tr>
<tr>
<td>D.</td>
<td>decreases decreases</td>
</tr>
</tbody>
</table>

\[ v_{air} = c \]

\[ v = \frac{c}{n} \]

- \( v < c \)
- frequency never change, so

\[ f = \frac{v}{\lambda_{water}} = \frac{c}{\lambda_{air}} \]

\[ \lambda_{water} < \lambda_{air} \]
16. Two resistors, made of the same material, are connected in series to a battery. The length of resistor X is twice that of resistor Y, and X has twice the cross-sectional area of Y.

Which of the following gives \( \frac{\text{resistance of } X}{\text{resistance of } Y} \)?

A. \( \frac{1}{4} \)
B. \( \frac{1}{2} \)
C. 1
D. 4

\[
\frac{R_X}{R_Y} = \frac{\rho_X \frac{L_X}{A_X}}{\rho_Y \frac{L_Y}{A_Y}} = \frac{2 \frac{L_Y}{A_Y}}{\frac{L_Y}{A_Y}} = 1
\]

\( L_X = 2L_Y \)
\( A_X = 2A_Y \)
\( \rho_X = \rho_Y \)
\( R = \rho \frac{L}{A} \)
17. The circuit shows a resistor $R$ connected in series with a battery and a resistor of resistance 10 $\Omega$. The emf of the battery is 20 V and it has negligible internal resistance. The current in the circuit is 1.0A.

Which of the following is the resistance of $R$?

A. 1.0 $\Omega$
B. 2.0 $\Omega$
C. 10 $\Omega$  \[ \text{C} \]
D. 20 $\Omega$

\[
\begin{align*}
\epsilon &= V \quad (r = 0) \\
I &= \frac{\epsilon}{R_{eq}} = \frac{V}{R_{eq}} \\
R_{eq} &= \frac{V}{I} \\
10 + R &= \frac{20}{I} \\
R &= 10\Omega
\end{align*}
\]
18. Three identical resistors are connected to a battery as shown.

Which of the following is a correct statement?

A. The current through X is greater than that through Z.
B. The potential difference across Z is greater than that across Y.  **B**
C. The potential difference across resistor X and Y together is the same as that across Z.
D. The current through Z is less than the total current through X and Y.
19. A current is established in a coil of wire in the direction shown.

The direction of the magnetic field at point P is

A. out of the plane of the paper.
B. into the plane of the paper. B
C. to the left.
D. to the right.

RHR – 2
- grab the wire with current and point your thumb in the direction of current
- your curled fingers follow direction of magnetic field
- outside the loop into the page
- inside the loop out of the page
20. Which arrangement of three point charges at the corner of an equilateral triangle will result in a zero electric field strength at the centre of the triangle, point P?

A. \(+Q\) \(-Q\) \(+Q\)
B. \(-Q\) \(+Q\) \(+2Q\)
C. \(+Q\) \(-2Q\) \(+Q\)
D. \(-Q\) \(-Q\) \(-2Q\)
21. The mass of a planet is twice that of Earth. Its radius is half that of the radius of Earth. The gravitational field strength at the surface of Earth is \( g \). The gravitational field strength at the surface of the planet is

A. \( \frac{1}{2} g \)
B. \( g \)
C. \( 2g \)
D. \( 8g \)
22. An electron enters the vacuum between two oppositely charged plates with velocity \( v \). The electron is followed by an alpha particle moving with the same initial velocity as the electron. A uniform magnetic field is directed out of the plane of the paper.

![Diagram showing an electron and an alpha particle with velocities and a magnetic field directed out of the plane of the paper.]

The electron’s path is undeflected. The path of the alpha particle will be

A. deflected out of the plane of the paper.
B. undeflected.  \( B \)
C. deflected upward.
D. deflected downward.
23. The Geiger–Marsden experiment provides evidence for

A. the existence of discrete atomic energy levels.
B. the existence of the neutron.
C. a dense positively charged nucleus.  
D. the stability of some nuclei.

24. A radioactive isotope has a half-life of two minutes. A sample contains sixteen grams of the isotope. How much time elapses until one gram of the isotope remains?

A. 6 minutes
B. 8 minutes
C. 10 minutes
D. 12 minutes
25. Data concerning nuclides are plotted using the axes below.

What are the axis labels for this graph?

<table>
<thead>
<tr>
<th></th>
<th>Y</th>
<th>X</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>binding energy per nucleon</td>
<td>number of nucleons</td>
</tr>
<tr>
<td>B</td>
<td>binding energy</td>
<td>number of protons</td>
</tr>
<tr>
<td>C</td>
<td>number of protons</td>
<td>binding energy per nucleon</td>
</tr>
<tr>
<td>D</td>
<td>number of nucleons</td>
<td>binding energy</td>
</tr>
</tbody>
</table>

A
26. Which of the following is true about beta minus (\( \beta^- \)) decay?

A. An antineutrino is absorbed.
B. The charge of the daughter nuclide is less than that of the parent nuclide.
C. An antineutrino is emitted.  \[ \boxed{C} \]
D. The mass number of the daughter nuclide is less than that of the parent nuclide.
27. A wave generator produces a power per unit length of 4.0 kW m\(^{-1}\) for waves of amplitude \(A\) and speed \(v\). The efficiency of the generator is constant. The power per unit length obtained from waves of amplitude 2\(A\) and speed 2\(v\) would be

A. 8.0 kW m\(^{-1}\).
B. 16 kW m\(^{-1}\).
C. 32 kW m\(^{-1}\).  
D. 64 kW m\(^{-1}\).

\[
\text{power per unit length} = \frac{1}{2} A^2 g v
\]
\[
\text{new power} = \frac{1}{2} (2A)^2 g (2v) = 8 \left[ \frac{1}{2} A^2 g v \right] = 8 \times 4
\]
28. The diagram shows the variation with wavelength of the power per unit wavelength \( I \) radiated from an area of 1 m^2 of two different bodies. Which of the following is a correct comparison of the temperature and emissivity of the two bodies?

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Emissivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.</td>
<td>same</td>
</tr>
<tr>
<td>B.</td>
<td>same</td>
</tr>
<tr>
<td>C.</td>
<td>different</td>
</tr>
<tr>
<td>D.</td>
<td>different</td>
</tr>
</tbody>
</table>

\( T_1 > T_2 \)

- The diagram shows that the intensity of radiation is higher for \( T_1 \) than for \( T_2 \) for the same area.
- Since the intensity is higher for \( T_1 \), it suggests that \( T_1 \) is at a higher temperature than \( T_2 \).
- The curves for emissivity are not shown in the diagram, but based on the intensity, it can be inferred that the emissivity might be different for the two bodies.

Therefore, the correct comparison is:

D. different, different
29. Which of the following is the most likely explanation for a rise in global sea level?

A. Thermal expansion of water  A
B. Melting of sea ice  not enough
C. Increase in rainfall
D. Thermal expansion of ice
30. The diagram shows an energy balance climate model for a planet.

The intensities of the reflected and radiated radiation are given in terms of the incident intensity $I$. Which of the following is the albedo of this planet?

A. 0.15  
B. 0.25  
C. 0.40  
D. 0.60

The albedo is calculated as follows:

$$albedo = \frac{\text{power (or energy) reflected from Earth}}{\text{power (or energy) incident upon Earth}}$$

$$= \frac{0.15I + 0.25I}{I} = \frac{0.40I}{I} = 0.40$$