1. A particle $P$ is moving in a circle with uniform speed. Which one of the following diagrams correctly shows the direction of the acceleration $a$ and velocity $v$ of the particle at one instant of time?

A. \[ a \quad v \]

B. \[ a \quad v \]

C. \[ a \quad v \]

D. \[ a \quad v \]

2. The centripetal force $F$ acting on a particle of mass $m$ that is travelling with linear speed $v$ along the arc of a circle of radius $r$ is given by

A. \[ F = \frac{v^2}{mr} \]

B. \[ F = mv^2r \]

C. \[ F = mr^2v \]

D. \[ F = \frac{mv^2}{r} \]
3. Which of the following diagrams represents the direction of the centripetal force $F$ acting on a car travelling in a circular path?

A.  

B.  

C.  

D.  

(1)

4. A satellite orbits the Earth at constant speed as shown below.

(a) Draw on the diagram

(i) an arrow labelled $F$ to show the direction of the gravitational force of the Earth on the satellite.

(ii) an arrow labelled $V$ to show the direction of the velocity of the satellite.

(2)
(b) Although the speed of the satellite is constant, it is accelerating. Explain why it is accelerating.

\[ \text{changing direction} \]

(2)

(c) Discuss whether or not the gravitational force does work on the satellite.

\[ \text{No, no change in } F_p \text{ or } F_e \text{. No work.} \]

(3)

(Total 7 marks)

5. This question is about the kinematics and dynamics of circular motion.

(a) A car goes round a curve in a road at constant speed. Explain why, although its speed is constant, it is accelerating.

\[ \text{changing its direction} \]

(2)
In the diagram below, a marble (small glass sphere) rolls down a track, the bottom part of which has been bent into a loop. The end A of the track, from which the marble is released, is at a height of 0.80 m above the ground. Point B is the lowest point and point C the highest point of the loop. The diameter of the loop is 0.35 m.

The mass of the marble is 0.050 kg. Friction forces and any gain in kinetic energy due to the rotating of the marble can be ignored. The acceleration due to gravity, \( g = 10 \text{ ms}^{-2} \).

Consider the marble when it is at point C.

(b) (i) On the diagram opposite, draw an arrow to show the direction of the resultant force acting on the marble.

(ii) State the names of the two forces acting on the marble.

(iii) Deduce that the speed of the marble is 3.0 ms\(^{-1}\).

\[
\sqrt{2(Mgh + \frac{1}{2}mv^2)} = v
\]

\[
2.96 \text{ m/s} = v \approx 3 \text{ m/s}
\]
(iv) Determine the resultant force acting on the marble and hence determine the reaction force of the track on the marble.

\[
\begin{align*}
F_c &= F_g = F_N \\
&= \frac{mg}{r} \\
&= \frac{0.075 \times 9.8}{0.125} \\
&= 6.0 N \\
F_N &= F_g = F_c \\
&= 6.0 N
\end{align*}
\]

(4)

(Total 12 marks)

6. This question is about circular motion.

A linear spring of negligible mass requires a force of 18.0 N to cause its length to increase by 1.0 cm.

A sphere of mass 75.0 g is attached to one end of the spring. The distance between the centre of the sphere M and the other end P of the unstretched spring is 25.0 cm, as shown below.

The sphere is rotated at constant speed in a horizontal circle with centre P. The distance PM increases to 26.5 cm.

(a) Explain why the spring increases in length when the sphere is moving in a circle.

\[
F = k \Delta x = 27 N
\]

\[
\text{mass} \times \text{force due to mass} = \text{net force needed to move mass in a circle}
\]

\[
\vec{F} \uparrow \text{ due to } \vec{a} \text{, new } \vec{F}
\]
(b) Determine the speed of the sphere.

\[ F = \frac{m v^2}{R} \]

\[ 27 = \frac{0.025 x 0.2}{0.26} \]

\[ \sqrt{\frac{27 x 26}{0.07}} = v \]

\[ 9.71 m/s = v \]

(Total 6 marks)

7. This question is about atomic models. The diagram below (not to scale) shows a simple model of the hydrogen atom in which the electron orbits the proton in a circular path of radius \( R \).

(a) On the diagram, draw an arrow to show the direction of

(i) the acceleration of the electron (label this \( A \)).

(ii) the velocity of the electron (label this \( V \)).

(b) State an expression for the magnitude of the electrostatic force \( F \) acting on the electron.

\[ F = \frac{kQq}{r^2} \]

(\( k = \text{constant} \))

\[ F = \frac{1000}{R^2} \]

\( \text{(won't do this till Electrostatics!)} \)
(c) The orbital speed of the electron is $2.2 \times 10^6$ m s$^{-1}$.

Deduce that the radius $R$ of the orbit is $5.2 \times 10^{-11}$ m.

\[
\frac{F_e}{m} = \frac{m v^2}{R} \implies R = \frac{m v^2}{F_e} = \frac{m v^2}{kE}\frac{1}{2}\]

\[
R = \frac{m v^2}{kE} = 5.2 \times 10^{-11} \text{ m}
\]

\[ \text{(3)} \]

(d) A more complex model of the atom suggests that the orbital radius can only take certain discrete values. This leads to the idea of discrete energy levels within the atom. Outline the evidence that supports the existence of discrete energy levels.

\[
\text{Bohr's Model} = \text{Line Spectra}
\]

\[
\text{chemically only certain f. of}
\]

\[
\text{light can be emitted from a}
\]

\[
\text{Hydrogen atom}
\]

\[ \text{(3)} \]

(Total 9 marks)