7 **(a)** Define simple harmonic motion.

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…………………………………………………………………………….... [2]

(b) **(i)** Define angular frequency ω and state its relationship to the periodic time T of simple harmonic motion.

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…………………………………………………………………….... [2]

(ii) The angular frequency ω of a simple pendulum undergoing small oscillations is related to its length L by the formula $\omega^2 = g/L$ where g is the acceleration due to gravity. Derive a formula for the period of small oscillations of the pendulum.

[1]

(iii) A small smooth ball is making small oscillations near the bottom of a smooth semi-circular saucer a shown in **Fig. 7.1**.

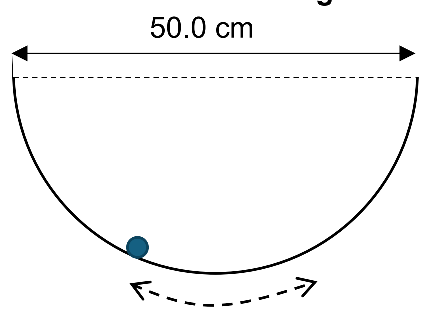

Fig. 7.1

With reference to **(b)(ii)**, determine the periodic time *T* of the oscillations of the ball. Explain how you arrived at your answer.

T = ………………….. [3]

(c) **(i)** State what is meant by an ideal gas.

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…………………………………………………………………………….. [2]

(ii) Show how the Ideal Gas Equation reduces to Boyle's Law under the right conditions. State those conditions.

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………………………………………………………………………… [2]

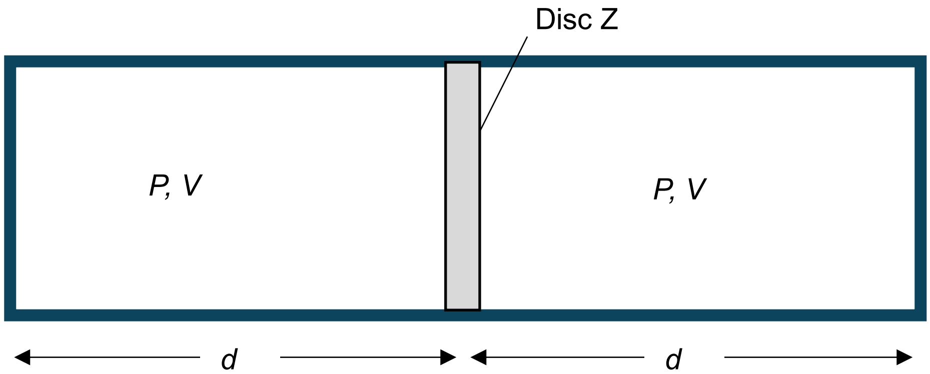

Fig. 7.2

A thin, frictionless disc Z of mass *m* divides an air-tight, cylindrical container into two equal chambers as shown in **Fig. 7.2**. The chambers contain an ideal gas, and the gas pressure is *P* in each of the two chambers. The length of each chamber is *d*, and the volume is *V*. The area of the disc is *A*. The disc can move freely and horizontally in the container.

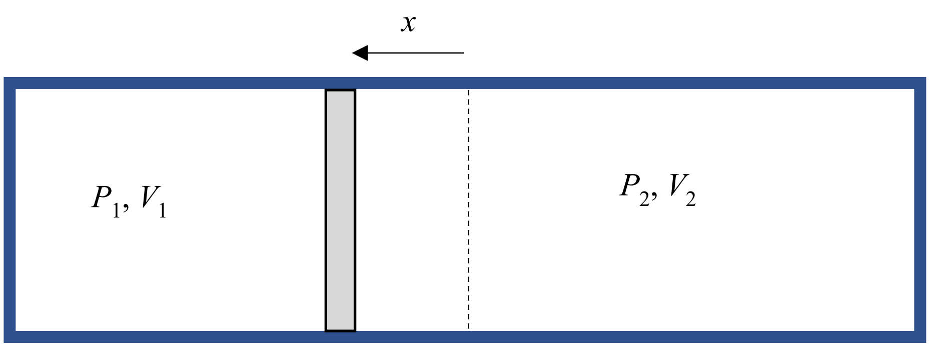

Fig. 7.3

The disc is now displaced to the left by a *small* distance *x*. The forces acting on the disc corresponding to pressures P_1 and P_2 are respectively F_1 and F_2. When released, the piston oscillates simple harmonically about its equilibrium position.

(iii) Draw the forces F_1 and F_2 acting on the disc in **Fig. 7.3**. [1]

(iv) Assuming Boyle's Law is valid, show that

$$F_1(d-x) = F_2(d+x) = PAd$$

when the disc is in the position shown in **Fig. 7.3**,

[2]

(v) Using Newton's Second Law, show that

$$ma = -2\frac{PAdx}{d^2 - x^2}$$

where a is the acceleration of the piston.

[2]

(vi) Hence derive an expression for the period T of motion of the disc.

[2]

(vii) Calculate T given that P = 100 Pa, A = 100 cm^2, d = 0.50 m and m = 1.0 kg.

T = ……………….. s [1]