

SECTION I (One hour)

Answer all questions in this section.

1. Optical fibres are being increasingly used in modern technology.
- (a) (i) What are optical fibres?
(ii) State the main physical property that makes the use of optical fibres so important today.
- (b) Describe one use of optical fibres in medicine.
- (5 marks)

2. The stability of a nucleus depends on the binding energy per nucleon for the particular nucleus.
- (a) What is binding energy?
- (b) Sketch a graph to show the binding energy per nucleon versus mass number for the natural existing nuclei. On this graph indicate ranges for possible
- (i) fission reactions and
(ii) fusion reactions
- (5 marks)

3. A series of thermodynamic processes are shown in the PV diagram of figure 1. In process ab 150 J of heat are added to the system, and in process cd 600 J of heat are added.

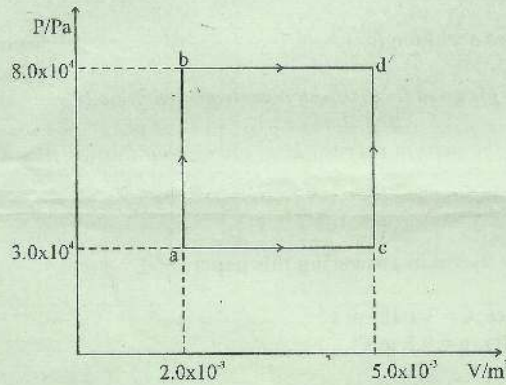


Figure 1

- (i) calculate the internal energy change in the process a b.
(ii) calculate the internal energy change in the process a b d.
- (4 marks)

4. Newton's Universal law of gravitation may be stated as

$$F = \frac{GM_1M_2}{r^2}$$

- (a) (i) Describe the different symbols in the equations.
(ii) What are the units for the physical quantity G?
- (b) Explain why an equation which is
- (i) not homogeneous with respect to units must be wrong
(ii) homogeneous with respect to units may none-the-less be wrong.
- (8 marks)

5. Rayleigh scattering by molecules is one cause of signal attenuation. Attenuation due to Rayleigh scattering depends on the wavelength (λ) of the signal and is proportional to $\frac{1}{\lambda^4}$.

- (a) What do you understand by
 - (i) Scattering and
 - (ii) signal attenuation
 - (b) If a signal of wavelength 850 nm is attenuated by 2.0 dB km⁻¹ because of Rayleigh scattering,
 - (i) Calculate the attenuation of a 1500 nm signal in the same medium.
 - (ii) What physical quantity has as unit the decibel?
- (7 marks)

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6. (a) Describe in relation to molecular behaviour,
 - (i) one way in which gases are similar to liquids but different from solids and
 - (ii) one way in which liquids are similar to solids but different from gases.
- (b) Describe one physical phenomenon in each case to demonstrate that
 - (i) matter is made up of tiny particles,
 - (ii) these particles are in random motion.
- (8 marks)

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7. (a) Explain why a charged particle moving with constant speed in a uniform magnetic field describes a circular path, if its initial velocity is perpendicular to the field lines.
- (b) An electron enters a uniform magnetic field of 0.5 T with a speed of 3.0×10^5 m s⁻¹.
 - (i) Calculate the centripetal force experienced by the electron
 - (ii) Suppose the electron starts losing speed, what are the consequences to the path and the environment of the electron?
- (8 marks)

Turn over

SECTION II (one and a half hours)

Answer all questions

Answer either 8 (a), (b) and (c) or 8 (d), (e), and (f).

EITHER 8 (a), (b) and (c)

8. (a) (i) Define the *specific (latent) heat of fusion* of a substance? (2 marks)
 (ii) Describe an experiment to show how the specific (latent) heat of fusion of ice can be determined. (8 marks)

- (b) (i) Ethyl alcohol has about one half the specific heat capacity of water. If equal masses of ethyl alcohol and water in separate beakers are supplied with the same amount of heat, compare the temperature changes of the two liquids. (2 marks)

- (ii) 10 kg of molten lead at its melting point of 327°C and 1.0 kg of ice at 0°C are placed inside an insulated chamber where they reach a common final temperature. Calculate the final temperature and the heat loss by the lead in the process.
 (specific heat of fusion of ice = $3.34 \times 10^5 \text{ J kg}^{-1}$
 specific heat capacity of water = $4.2 \times 10^3 \text{ J kg}^{-1} \text{ }^\circ\text{C}^{-1}$
 specific heat capacity of lead = $1.28 \times 10^3 \text{ J kg}^{-1} \text{ }^\circ\text{C}^{-1}$
 specific latent heat of fusion of lead = $2.45 \times 10^3 \text{ J kg}^{-1}$

- (c) Why is it possible to hold a lit match, even when it is burning to within a few millimetres of your fingertips? (6 marks)

(2 marks)
 (Total = 20 marks)

OR 8 (d), (e), and (f)

- (d) (i) Define Young's modulus (2 marks)
 (ii) Describe an experiment to show how the Young's modulus for a metal wire can be determined. (9 marks)

- (e) Figure 2 shows a chain hung from a support

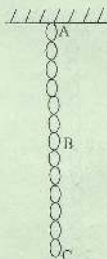


Figure 2

- Where is there maximum stress on the chain: A, B, or C? Explain (3 marks)

- (f) A load of 102 kg is supported by a wire of length 2.0 m and the cross-sectional area of 0.10 cm^2 . If the wire is stretched by 2.2 mm, calculate
 (i) the stress
 (ii) the strain
 (iii) Young's modulus (6 marks)

Answer either 9 (a) and (b) or 9(c) and (d)

EITHER 9 (a), (b)

9. (a)

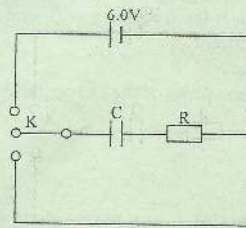


Figure 3

In the circuit diagram in figure 3, the capacitor, C, is first fully charged by using a 6.0 V battery and the two way switch K. It is then discharged. The figure 4 shows how the charge Q, on the capacitor C, changes with time during the discharge

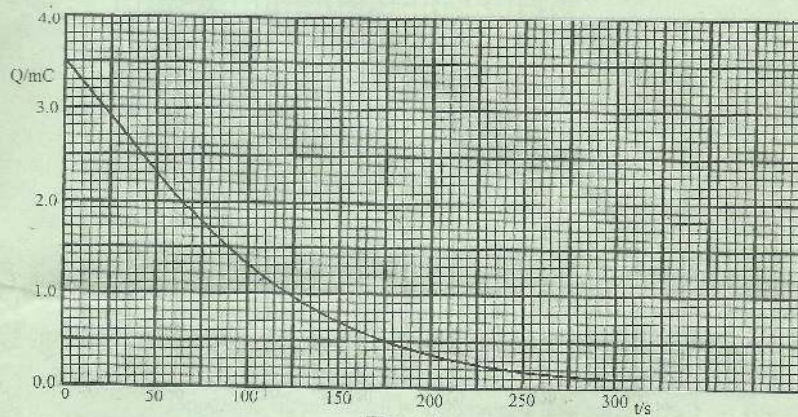
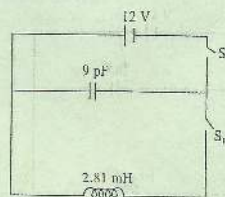


Figure 4

Use the graph to answer the following questions.

- (i) What is the capacitance of the capacitor? (3 marks)
- (ii) Estimate the initial current through the resistor during the discharging process, hence calculate the resistance of the resistor and the time constant. (6 marks)
- (iii) On the same axes draw graphs to show how the voltage V_C across the capacitor and V_R across the resistor vary with time during charging. Indicate values where appropriate. (5 marks)

(b)



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Figure 5

Figure 5 is an LC circuit with an inductance of 2.8 mH and a capacitance of 9.0 pF. The capacitor is initially charged with a 12 V battery when switch S is opened and switch S₂ closed. S₁ is then closed at the same instant that S₂ is opened. If the frequency of S₁ and S₂, opening and closing corresponds to the resonance frequency for LC circuit

- (i) calculate this frequency (2 marks)
- (ii) what are the maximum values of the charge on the capacitor and current in the circuit? (4 marks)

OR 9 (c) and (d)

- (c) A car of mass 1000 kg is initially at rest. It then moves along a straight road for 20 minutes and comes to rest again. The momentum – time graph for the motion is shown in figure 6.

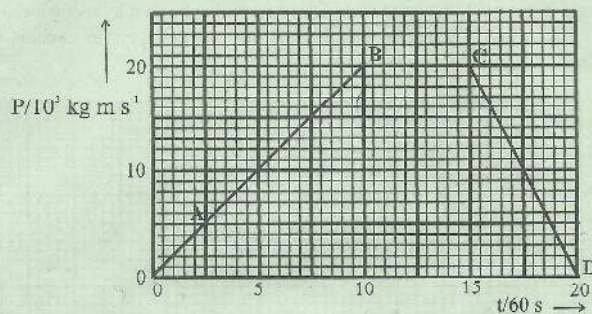


Figure 6

Use the graph to answer the following questions

- (i) What are the resultant forces acting on the car during the parts of the motion labelled AB, BC and CD? (6 marks)
 - (ii) Calculate the total displacement of the car for the 20 minutes. (3 marks)
 - (iii) Sketch a displacement – time graph for the car during the 20 minutes. (5 marks)
- (c) If, when travelling at the maximum speed, the car had struck and remained attached to a stationary vehicle of mass 1500 kg.
- (i) With what velocity would the interlocked vehicles have travelled immediately after collision? (3 marks)
 - (ii) Calculate the kinetic energy of the car just prior to this collision and the kinetic energy of the interlocked vehicles just afterwards. Comment on the values obtained. (3 marks)

Answer Either 10 (a), (b) and (c) or 10 (d), (e), (f)

EITHER 10 (a), (b) and (c)

10. (a) Explain briefly the difference between an emission spectrum and an absorption spectrum. Describe an observation to illustrate each of the spectra

(6 marks)

(b)

Figure 7

Figure 7 shows some of the possible energy levels of the hydrogen atom.

(i) Why are the energy values negative?

(1 mark)

(ii) Explain briefly how figure 7 can be used to account for the fact that the ionisation energy of the hydrogen atom is 13.6 eV

(3 marks)

(iii) Calculate the highest possible frequency in the line spectrum of hydrogen from transition between the five spectral lines shown in the diagram. In what region of the electromagnetic spectrum does this radiation lie?

(3 marks)

(iv) Which transition in figure 7 corresponds to the maximum wavelength that would be visible to the eye?

(3 marks)

(c) In an alpha scattering experiment, the fraction of incident alpha particles reflected back through more than 90° is very small. How does this result lead to the idea that an atom has a nucleus,

- (i) whose diameter is small compared with the atomic diameter, and
- (ii) which contains most of the atomic mass?

(4 marks)

