JUNE 2002

1. Optical fibres are being increasingly used in modern technology
   i. What are optical fibres
   ii. State the main physical property that makes optical so important today
   iii. Describe the use of optical fibres in medicine.
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 versus mass number for the natural existing nuclei.

   On the graph, indicate ranges for possible
   i. Fission reactions
   ii. Fusion reactions
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 bd, 600 J of heat are added.

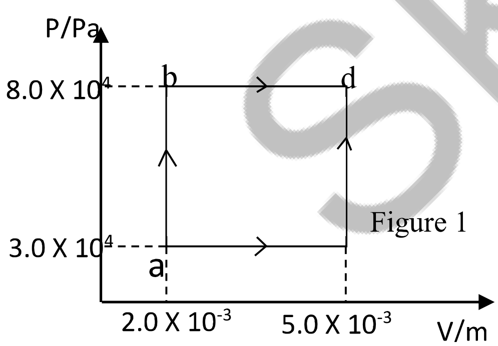


Figure 1

   i. Calculate the internal energy change in the process ab.
   ii. Calculate the internal energy change in the process abd.

4. (a) Newton's law of gravitation may be stated as

$$F = \frac{Gm_1m_2}{r^2}$$

   i. Describe the different symbols in the equation
   ii. What are the units for the physical constant 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 non – the less be wrong.

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 $dBkm^{-1}$ because of Rayleigh scattering

   i) Calculate the attenuation of 1500 nm signal in the same medium.

   ii) What physical quantity has as unit decibel?

6. (a) Describe in relation to molecular behavior

   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 phenomenon in each case to demonstrates that

   (i) Matter is made up of tiny particles (ii) These particles are in random motion

7. (a) Explain why a charge particle moving in a constant uniform magnetic field describes a circular path, if its velocity is perpendicular to the field lines.

   (b) An electron enters a uniform magnetic field of 0.5 T with a speed 3.0×10^5 ms^{-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?

SECTION II

8. (a) (i) Define the specific latent heat of fusion of a substance.

   (ii) Describe an experiment to show how the specific latent heat of fusion of ice can be determined

   (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 change for the two liquids.

   (ii) 10 kg of molten lead at its melting point of 327^0C and 1.0 kg of ice at 0^0C are placed inside an insulated chamber where they reach a common final temperature. Calculate the final temperature and the heat lost by the lead in the process.

   Specific latent heat of fusion of ice = 3.34×10^5 Jkg^{-1}; Specific heat capacity of water = 4.2×10^3 $Jkg^{-1}{}^0C^{-1}$

   Specific heat capacity of lead = 1.28×10^3 $Jkg^{-1}{}^0C^{-1}$; Specific latent heat of fusion of lead = 2.45×10^3 Jkg^{-1}

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

   (d) (i) Define Young's modulus

   (ii) Describe an experiment to show how the Young's modulus for a metal wire can be determined.

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

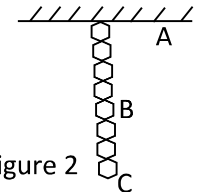


Figure 2

Where is the maximum stress on the chain; A, B, or C? Explain.

f) A load of 102 kg is supported by a wire of length 2.0 m and the cross section of the wire is 0.10 cm^2. If the wire is stretched by 2.2 mm, calculate

9. (a) In the circuit in figure 3, the capacitor is fully charged by using a 6.0 V battery and the two way switch K. it is then discharged. Figure 3 below shows how the charge, Q on the capacitor, C cha ime during the discharge.

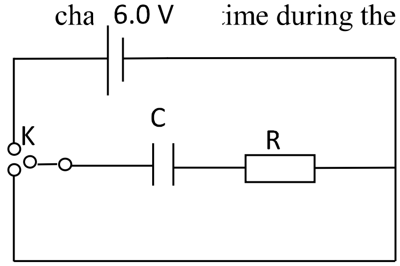
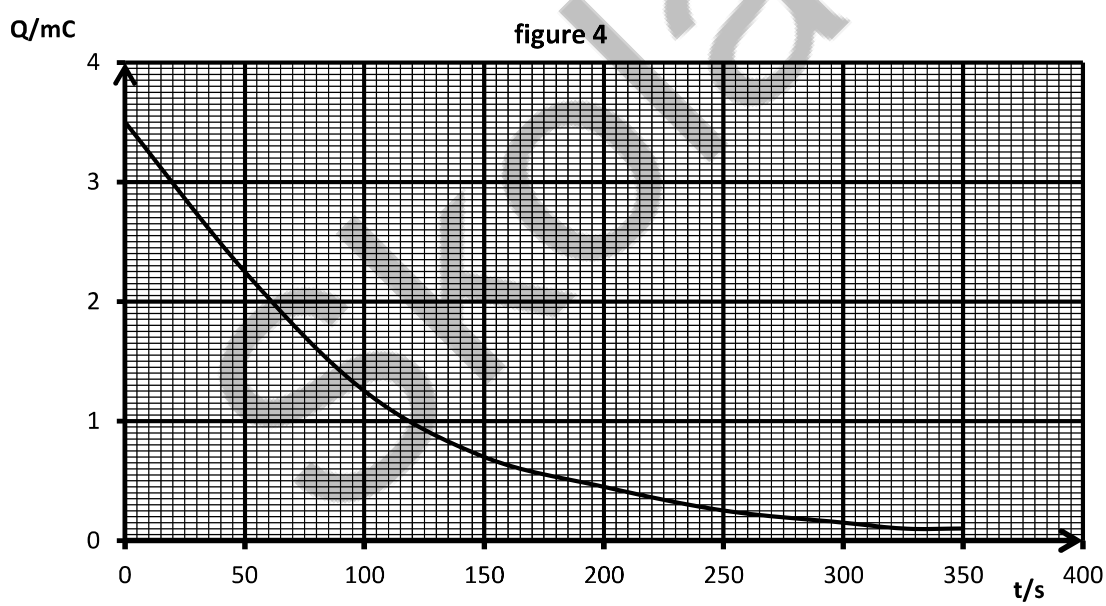


Figure 3

figure 4



Use the graph to answer the following questions

i. What is the capacitance of the capacitor?

ii. Estimate the initial current through the resistor during the discharging process, hence calculate the resistance of the resistor and the time constant

iii. On the same axes, draw graphs to show how the voltage V_c across the capacitor and V_R across the resistor varies with time during charging. Indicate values where appropriate

(b)

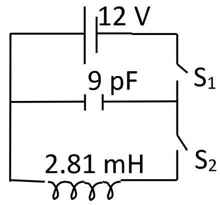


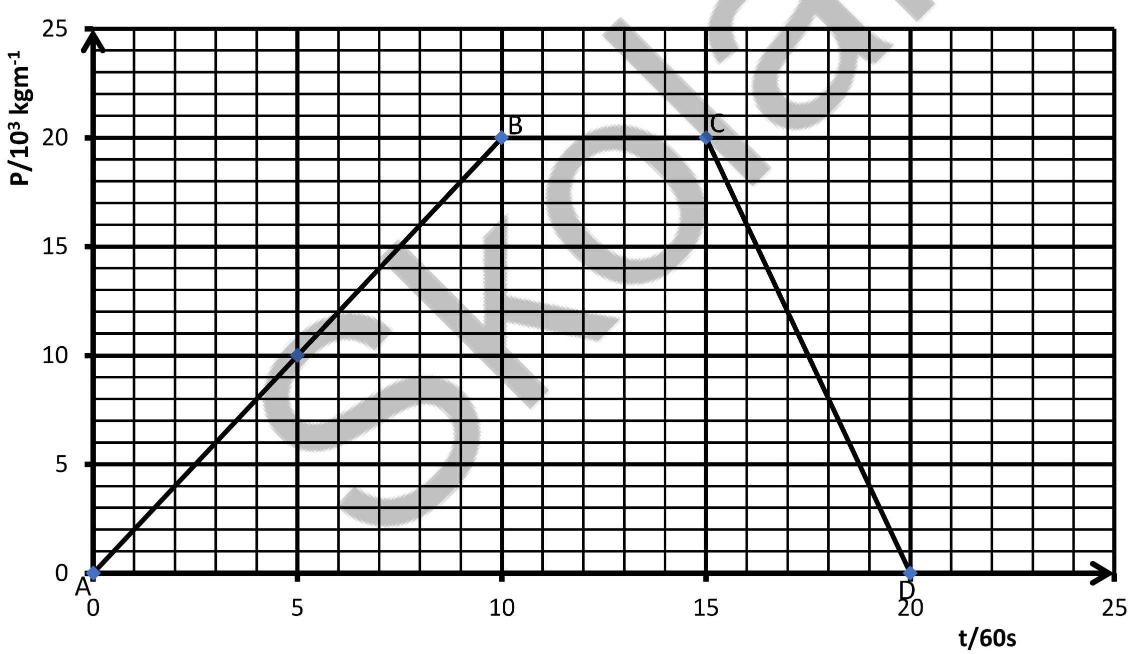
Figure 5

Figure 5 is an LC with an inductance of 2.81 mH and a capacitance of 9.0pF. The capacitor is initially charged with a 12 V battery switch S_1 is opened and S_2 closed. S_1 is then closed and S_2 opened. If the frequency of S_1 and S_2, opening and closing corresponds to the resonance frequency for LC circuit.

(i) Calculate this frequency

(ii) What are the maximum values of the charge on the capacitor and current in the circuit?

(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



Use the graph to answer the following questions

(i) What are the resultant forces acting on the car during the parts of the motion labeled AB, BC and CD?

(ii) Calculate the total displacement of the car during the 20 minutes

(iii) Sketch a displacement – time graph for the car during the 20 minutes.

(d) If, when travelling at the maximum speed, the car had struck and remained attached to a stationary vehicles of mass 1500 kg.

i. With what velocity would the interlocked vehicles have travelled immediately after the collision?

ii. Calculate the kinetic energy of the car just prior to the collision and the kinetic energy of the interlocked vehicles just after the collision. Comment on the values obtained.

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

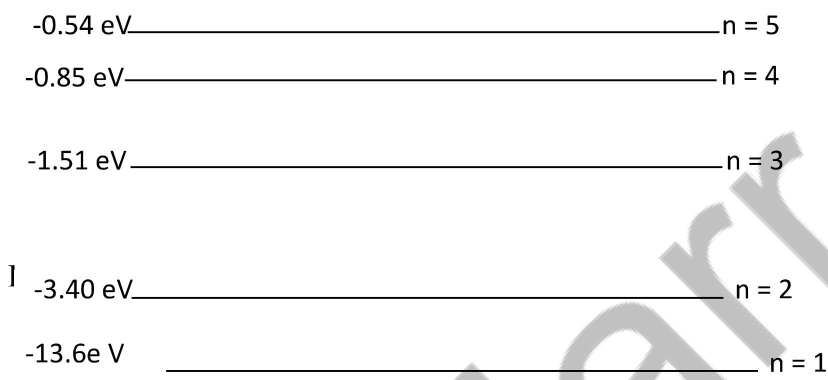


Figure 7 shows some of the possible energy levels of the hydrogen atom

(i) Why are the energy levels negative?
(ii) Explain briefly how figure 7 can be used to account for the fact that the ionization energy of the hydrogen atom is 13.6 eV
(iii) Calculate the highest possible frequency in the line spectrum of hydrogen from the transition between the five spectral lines shown in the diagram. In what region of the electromagnetic spectrum does this transition lie?
(iv) Which transition in figure 7 corresponds to the maximum wavelength that would be visible to the eye?
(c) in an α – scattering experiment, the fraction of incident alpha particles reflected back through more than 90^0 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?

(d) Explain briefly the difference between electromagnetic waves and mechanical waves. Give one example of each.
(e) Distinguish between stationary and progressive waves?
Describe briefly how best stationary waves can be produced from two progressive waves. Draw diagrams to show the superposition of the waves involved to produce the resultant effect.
(f) In an experiment to investigate the properties of stationary waves, one end of a rubber cord is attached to a vibrator, the frequency of which can be varied, and the other end to a rigid support. Figure 8 is a diagram of the cord drawn to scale showing the cord vibrating at one of its harmonics.

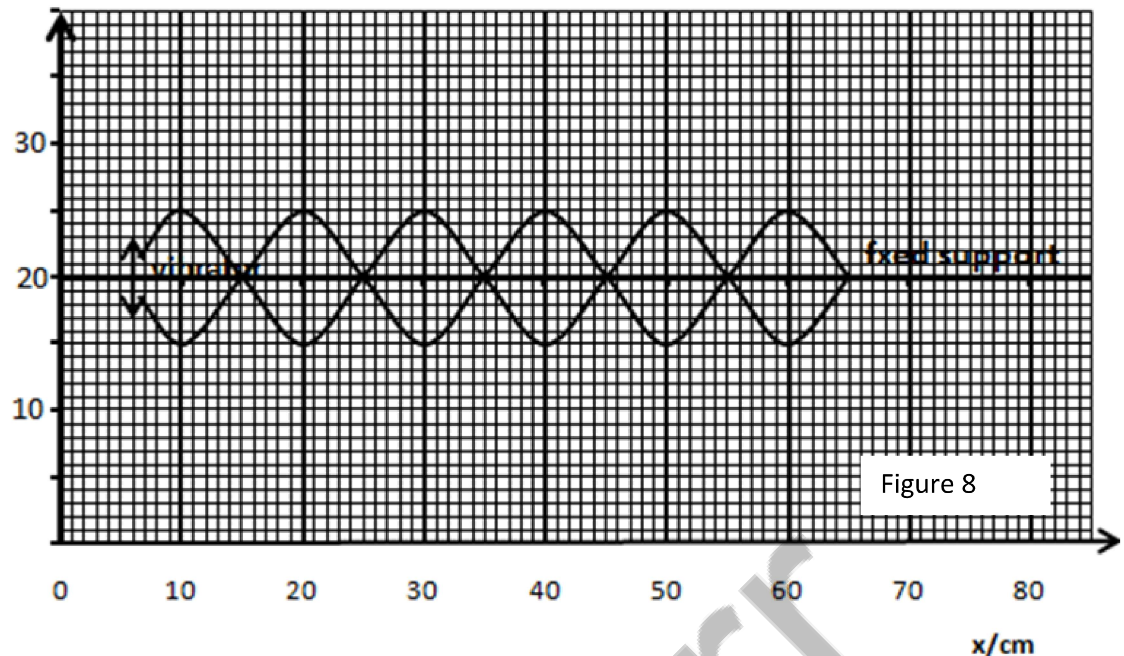


Figure 8

i.

ii.

iii. If the frequency of the vibrator is 600 Hz, calculate the wave speed, and the fundamental frequency of the cord when supported in this manner.

STUDENT'S PROPOSED ANSWERS TO JUNE 2002