Cork Institute of Technology

Higher Certificate in Science in Applied Biology - Stage 1

(National Certificate in Science in Applied Biology – Stage 1)

(NFQ – Level 6)

Summer 2005

Physics

(Time: 3 Hours)

Answer **FIVE** questions only.

SHOW ALL WORKING.

Examiners: Dr. C. Frehill
Dr. M. E. Woods
Dr. T. Bereford

$k = 1.38 \times 10^{-23}$ J K^{-1}; $h = 6.6 \times 10^{-34}$ J s;
$e = 1.6 \times 10^{-19}$ C; $c = 3 \times 10^{8}$ ms^{-1};
$g = 10$ ms^{-2} ; $N_A = 6 \times 10^{23}$ mol^{-1};
1 a.m.u. = 1.66×10^{-27} kg.

Q1. (a) Define the following terms:

(i) *diffraction*

(ii) *monochromatic light source* [4 marks]

(b) Sketch a diagram of an *optical spectrometer*. Label the important parts of the spectrometer and explain their function. Show the optical spectrometer set-up to measure the wavelengths of emission lines from a light source using a suitable optical device.

[6 marks]

(c) A student performs an experiment to determine the wavelength of the light from a sodium discharge lamp using Young's slits and a spectrometer. The separation between the slits was 0.5 mm. When the telescope of the spectrometer was moved across 8 bright fringes, an angular change of 0.54^{o} was measured.

(i) State the *diffraction equation* for *bright fringes* and hence determine the *wavelength* of the sodium line.

(ii) Sketch a labelled diagram of the appearance of the fringes in the telescope eyepiece.

(ii) State TWO differences between the appearance of the fringes produced by Young's slits and those from a diffraction grating [with smaller slit separation] for the same light source. [10 marks]

Q2. (a) The inside of an oil tank has a width of 0.80 m a length of 2.0 m and a height of 1.5 m. It is full of oil of density 900 kg m^{-3}. The tank has negligible dimensions and mass.

(i) State the difference between *mass* and *weight*.

(ii) Calculate the *mass* and the *weight* of the oil in the tank.

(iii) What is the *pressure* at a depth of 1.2 m in the tank? [10 marks]

(b) *Name the effect* and explain why water rises up a glass tube with a narrow bore when it is placed in water. [4 marks]

(c) Blood flows through an artery of cross-sectional area 3.0×10^{-4} m^2 with a velocity of 0.25 ms^{-1}. Eventually the blood flows through thousands of capillaries of total cross-sectional area 0.15 m^2.

(i) State the equation for the *volume flow rate* of a fluid.

(ii) State the *Equation of Continuity* for flow.

(iii) Determine the *flow velocity* in the capillaries. [6 marks]

Q3. (a) An atom of Carbon-13 consists of 6 protons, 6 electrons and 7 neutrons.

(i) Define the *mass number [A]* and *atomic number [Z]* of a nuclide.

(ii) State the values of *mass number* and *atomic number* for Carbon-13.

(iii) Define an *isotope*. [6 marks]

(b) Radon-220 has a decay constant $\lambda = 1.33 \times 10^{-2}$ s^{-1}. Initially there are 6.0×10^{25} radioactive nuclei present. Determine:

(i) the *half-life* $[T_{1/2}]$ for radon.

(ii) the *initial activity [dN/dt]* of the source. [9 marks]

(c) (i) Describe the *nature* of α-particles and β-particles.

(ii) An unknown radioactive source emits either α-particles or β-particles. How could you determine *experimentally*, which *type* of particles was emitted by the source?

[5 marks]

Q4. (a) An ice skater of mass 80 kg travelling horizontally from left to right with a velocity of 10.0 ms^{-1} collides with a second skater of mass 60 kg, travelling horizontally from right to left with a velocity of 4.0 ms^{-1}. The two skaters cling onto each other after collision.

(i) State the *Law of Conservation of Linear Momentum*.

(ii) Determine the *velocity* and *direction* of the two skaters after collision. [10 marks]

(b) A boulder of mass 25 kg, which is initially stationary, falls off a cliff from a height of 150 m and drops vertically downwards.

(i) State the *Law of Conservation of Energy*.

(ii) Calculate the *initial Potential Energy* of the boulder.

(iii) Determine the *Kinetic Energy* of the boulder when it is at a height of 90 m from the ground. [10 marks]

Q5. (a) An optical inspection technique gives the apparent depth of a flaw as 40 mm below a glass surface. If the refractive index of the material is 1.6 what is the *actual (real) position* of the flaw below the surface? [4 marks]

(b) Draw a ray diagram to illustrate how a *magnifying glass* (*biconvex converging lens*) produces a magnified image of an object. [4 marks]

(c) An object is placed 12 cm from a convex lens of focal length 18 cm. Calculate the *distance* of the image from the lens and its *magnification*. [6 marks]

(d) What is *total internal reflection*? Explain *how* it occurs for light travelling from one material to another and the *necessary conditions* for it to occur. Use ray diagrams to support your answer. Give ONE example of an *application* in which the phenomenon is readily applied. [6 marks]

Q6. (a) (i) Explain what is meant by *specific heat capacity* and *specific latent heat of vapourisation*.

(ii) Explain what happens to ice when latent heat is supplied to it at 0^oC [7 marks]

(b) Calculate how much *energy* is required to cool down 0.6 kg of water at 18^oC to a final temperature of 6^oC. [6 marks]

(c) Are two cubes of ice at 0^oC, each of mass 100 g, sufficient to cool down the water in (b)? [7 marks]

[*The specific heat capacity of water is 4200 J* kg^{-1} C^{-1}. *The specific latent heat of fusion of ice is 335 kJ* kg^{-1}.]

Q7. (a) Explain what is meant by *scalar* and *vector* properties. Give ONE example of a *scalar* property and ONE example of a *vector* property. [4 marks]

(b) At the Olympics, a weight-lifter lifts 120 kg straight upwards through a distance of 1.9 m in 0.5 s at a constant speed. What *power* does the weight-lifter produce while doing this? [5 marks]

(c) A train of mass 2000 kg is travelling at 72 km hr^{-1} when the brakes are applied. It decelerates at 2.0 ms^{-2}. Determine:

(i) the *braking force;*

(ii) the *time taken* for the train to stop;

(iii) the *distance travelled* after a time of 5.0 seconds from when the brakes were applied. [11 marks]