

# Cork Institute of Technology

## Bachelor of Science in Applied Biosciences – Stage 1

(NFQ level 7)

Autumn 2007

### Physics

(Time: 3 Hours)

Answer **FIVE** questions only.

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**SHOW ALL WORKING.**

$$h = 6.6 \times 10^{-34} \text{ J s}; \quad c = 3 \times 10^8 \text{ ms}^{-1};$$
$$g = 9.81 \text{ ms}^{-2}; \quad e = 1.6 \times 10^{-19} \text{ C};$$

- Q1 (a) (i) Define the following scientific terms: *Mass*, *Energy*.
- (ii) The sum of which TWO types of *energy* are conserved in a gravitational field, when air resistance is ignored? (6 marks)
- (b) A rural train consist of a locomotive and carriage. The carriage has a mass 12000 kg. The locomotive and carriage are initially stationary. As they depart from a station, the locomotive pulls the carriage with a force of 20 kN. The locomotive and carriage accelerate uniformly for a distance of 1.5 km in a time of 42.4 seconds.
- Calculate:
- (i) the *work done* by the locomotive;
- (ii) the *power* of the locomotive
- (iii) the *final velocity* of the train. (14 marks)
- Q2 (a) A cannon of mass 250 kg fires a cannon ball of mass 4.0 kg with a velocity of  $180 \text{ ms}^{-1}$ .
- (i) State (in words) the *Law of Conservation of Linear Momentum*.
- (ii) Hence determine the *recoil velocity* of the cannon. (10 marks)
- (b) (i) Define: *Scalar properties*; *vector properties*.
- (ii) State ONE example of a *scalar property* and ONE example of a *vector property*. (4 marks)
- (c) A groundsman marking out the lines on a pitch walks 90 m due North, then 40 m due East and finally 90m due South, before he runs out of white paint. The walk takes 4 minutes.
- Determine:
- (i) his *displacement*;
- (ii) his *average speed*. (6 marks)

- Q3 (a) State *Ohm's Law*. (2 marks)
- (b) Resistors  $R_1 = 4.0 \, \Omega$ ,  $R_2 = 8.0 \, \Omega$  and  $R_3 = 12.0 \, \Omega$  are connected together in parallel. A battery with an emf  $\varepsilon = 6.0 \, \text{V}$  is connected to the parallel resistors.
- Draw the *circuit diagram*.
  - Determine the *equivalent resistance* ( $R_{eq}$ ) of the circuit.
  - Determine the electrical *current*  $I_2$  through  $R_2$ .
  - Determine the *power*  $P$  dissipated in  $R_1$ . (14 marks)
- (c) An electric fire radiator is made from nichrome wire of resistivity  $\rho = 1.15 \times 10^{-8} \, \Omega\text{m}$ . The wire has a length of 85 cm and a cross-sectional area of  $3.2 \times 10^{-6} \, \text{m}^2$ . Determine the *resistance*  $R$  of the radiator wire. (4 marks)
- Q4 (a) (i) Describe the *nature* of  $\alpha$ -particles,  $\beta$ -particles and  $\gamma$ -rays.
- (ii) Compare the *ionising ability* of the three types of radiation.
- (iii) Name ONE type of *radiation detector*. Briefly explain how the type of radiation emitted by a radiation source may be determined by a simple experiment incorporating the detector. (10 marks)
- (b) The radioactive nucleus  $^{226}_{88}\text{Ra}$  decays by alpha emission to  $^A_Z\text{Rn}$ . Write the *nuclear equation* for this reaction and replace  $A$  and  $Z$  by their correct values. (3 marks)
- (c) A sample of a radioactive material initially contains  $6.4 \times 10^{24}$  radioactive atoms. The half-life is 22 days.
- How many radioactive atoms remain after 88 days?
  - State the *half-life equation*. Hence determine the *decay constant*  $\lambda$  (units:  $\text{s}^{-1}$ ) for the material. (7 marks)
- Q5 (a) Draw a diagram of an *optical spectrometer* fitted with a diffraction grating and suitable for viewing Cadmium or Sodium light sources. Label the important parts of the spectrometer and explain their function. (12 marks)
- (b) A plane diffraction grating has 500 lines per mm and is illuminated with monochromatic light. A second order bright line is observed through the telescope at an angle of  $37^\circ$  from the centre.
- Calculate the *wavelength* of the light and express it in *nanometers*. (8 marks)

Q6 (a) What is meant by (i) *specific heat capacity* and (ii) *thermometric property*? (4 marks)

(b) How much *heat* energy is required to change 25 kg of ice at  $-10^{\circ}\text{C}$  to steam at  $100^{\circ}\text{C}$ ?

[The specific heat capacity of ice is  $2.1 \text{ kJ kg}^{-1}\text{C}^{-1}$ ; the specific heat capacity of water is  $4.2 \text{ kJ kg}^{-1}\text{C}^{-1}$ ; the specific latent heat of fusion of ice is  $335 \text{ kJ kg}^{-1}$ ; the specific latent heat of vaporisation of water is  $2.26 \text{ MJ kg}^{-1}$ ]

(12 marks)

(c) State the three principle methods of *heat transfer*. Give a brief description of **ONE** of these processes. (4 marks)

Q7 (a) A porpoise emits a sound wave that has a wavelength of 2.5 cm. The speed at which the sound travels in seawater is  $1470 \text{ ms}^{-1}$ . Determine the *frequency* of the wave. (5 marks)

(b) What is the *force* acting on the bottom of a rectangular aquarium containing water to a depth of 1.5m? The base of the aquarium has a width of 1m and length 2m.

[The density of water  $1000 \text{ kg m}^{-3}$ ]

(7 marks)

(c) A car has petrol flowing through a pipe of cross-sectional area  $4.5 \times 10^{-5} \text{ m}^2$  at a velocity of  $1.0 \times 10^{-2} \text{ ms}^{-1}$ . The petrol then flows into a narrow tube of cross-sectional area  $1.5 \times 10^{-6} \text{ m}^2$ .

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

(ii) Determine the *velocity* of flow in the *narrow tube*.

(8 marks)