

**CORK INSTITUTE OF TECHNOLOGY
INSTITIÚID TEICNEOLAÍOCHTA CHORCAÍ**

Autumn Examinations 2015

Module Title: Heat and Light (CA)
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Module Code: **PHYS6044**

School: Science

Programme Title: Bachelor of Science (Hons) – Herbal Science, Year 1
 Bachelor of Science (Hons) – Nutrition and Health Science, Year 1
 Bachelor of Science (Hons) – Pharmaceutical Biotechnology, Year 1
 Bachelor of Science in Applied Biosciences, Year 1

Programme Code: SHERB_8_Y1
 SNHSC_8_Y1
 SPHBI_8_Y1
 SBIOS_7_Y1
 SCEBS_8_Y1

External Examiner(s): **Mr Joe Haugh, Dr. John Houlihan**
Internal Examiner(s): **Ms E. Baldwin**

Instructions: **Answer any 4 questions**

Duration: 2 hours

Sitting: Autumn 2016

Requirements for this examination:

Non programmable calculator allowed, Mathematical Tables allowed

<p>Note to Candidates: Please check the Programme Title and the Module Title to ensure that you have received the correct examination.</p>

<p>If in doubt please contact an Invigilator.</p>
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Question 1

- a) State the factors on which the rate of heat loss by conduction through a solid material depends. In each case, state whether a higher value for that factor causes the rate of heat loss to increase or decrease. Hence give the formula for the rate of heat loss by conduction through a solid material. (6 marks)
- b) A refrigerator is 2.5m high and 1.5m wide. It is lined with 3cm thick insulation whose thermal conductivity is $0.04 \text{ Wm}^{-1}\text{K}^{-1}$. The interior temperature is kept at 4°C while the temperature at the outside surface is 25°C . At what rate is heat being removed from the unit? (8 marks)
- c) An oven is in the form of a cube of sides 100 cm. What power must be supplied to maintain it at a temperature of 250°C in an environment at 20°C ? Take the emissivity to be 0.9 (11 marks)

Question 2

- a) Name and explain three methods of heat transfer, describe examples in each case. (10 marks)
- b) Define specific heat capacity. An aluminium pan of mass 400 g is initially at 18°C . What mass of water, at an initial temperature of 95°C , must be added to produce a final equilibrium temperature of 40°C ? (Relevant specific heat capacities (in $\text{J/kg}\cdot^{\circ}\text{C}$): water: 4186; aluminium: 900.) (12 marks)
- c) Would you expect a 30cm rod made from Aluminium to expand more than a 30cm rod made from glass if both rods are heated from 10°C to 40°C ? Explain your answer. (3 marks)

Question 3

- a) State Snell's Law and explain the symbols used (4 marks)
- b) Draw diagrams to illustrate the following (8 marks)
- A ray of light travelling from a dense medium into a rarer medium. Show the incident angle to be about 45° to the normal
 - A ray of light travelling from a medium of low density to a medium of higher density. Show the incident angle to be about 45° to the normal
 - A ray of light travelling from a medium of low density to a medium of higher density with an incident angle 90° to the normal
- c) A light ray in water passes into glass, it travels through the glass and emerges into air. If the ray strikes the water/glass boundary at an angle of 25° , what is the angle of refraction when the light emerges from the glass? Refractive index of glass is 1.53 and the refractive index of water is 1.33 (8 marks)

- d) When white light passes through a prism, blue light is bent more than red light. Why?
(give any relevant equations) (5 marks)

Question 4

- a) Explain the following terms, use diagrams to illustrate your answer where appropriate
- Diffraction of light
 - Constructive interference,
 - Monochromatic light
- (6 Marks)
- b) Describe the pattern which will be seen on a screen positioned a short distance away from a diffraction grating if the diffraction grating is illuminated by white light.
(5 marks)
- c) Cadmium has blue lines at 569 nm and 580 nm. Using a diffraction grating with 650 lines per mm, find the angular separation of these lines in third order. (10 marks)
- d) What is the highest order spectrum that will be visible on a screen, a distance away from the diffraction grating, using the light source and diffraction grating described above? (4 marks)

Question 5

- a) State the rules for the formation of images in convex and concave lenses. Draw diagrams to illustrate the rules. (12 marks)
- b) A microscope comprises a convex objective lens of focal length 10 mm and an eyepiece (also a convex lens) of focal length 8 cm. If an object is placed 15 mm in front of the objective, calculate the final image position and the overall magnification. The separation between the objective and the eyepiece is 10 cm. (13 marks)

Equation sheet and constants

Stefan Boltzmann constant,

$$\sigma = 5.6704 \times 10^{-8} \text{ W/m}^2 \text{ K}^4$$

$$Q = mc\Delta T$$

$$Q = ml$$

$$Q = \frac{kA\Delta T t}{d}$$

$$H = \frac{kA\Delta T}{d}$$

$$Q = e\sigma AT^4 t$$

$$H = e\sigma AT^4$$

$$H = e\sigma A(T_{\text{surface}}^4 - T_{\text{environment}}^4)$$

$$\Delta l = l_o \alpha \Delta T$$

$$H = \frac{A\Delta T}{R_1 + R_2}$$

$$R = \frac{d}{k}$$

Wavelength of violet light = 400 nm,

Wavelength of red light = 700 nm

Speed of light, $c = 3 \times 10^8 \text{ ms}^{-1}$

$$n_1 \sin \theta_i = n_2 \sin \theta_r$$

$$\frac{n_1}{n_2} = \frac{\text{Real depth}}{\text{Apparent Depth}}$$

$$\frac{1}{f} = (n-1) \left(\frac{1}{r_1} + \frac{1}{r_2} \right)$$

$$m = -\frac{v}{u}$$

$$\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$$

$$m_\theta = \frac{\theta'}{\theta} = \frac{P_n}{u} = \left(\frac{1}{f} - \frac{1}{v} \right) P_n$$

$$n\lambda = d \sin \theta$$

$$y = \frac{m\lambda L}{d}$$

$d = (1/\text{number of lines per unit length})$

