KABARAK UNIVERSITY

SUPPLEMENTARY/SPECIAL EXAMINATIONS

2008/2009 ACADEMIC YEAR

FOR THE DEGREE OF BACHELOR OF EDUCATION SCIENCE

COURSE CODE: **PHYS 121**

COURSE TITLE: HEAT & THERMODYNAMICS

STREAM: **Y1S1**

DAY: **THURSDAY**

TIME: **9.00 – 11.00 A.M.**

DATE: **19/03/2009**

INSTRUCTIONS

Answer **QUESTION 1** and **ANY OTHER TWO**

PLEASE TURN OVER

Question 1 (30 marks)

(a) Define temperature (2 marks)

(b) State any 5 physical properties of materials which change sufficiently with temperature that can be used as the bases for thermometers.

(5 marks)

(c) Explain why a thermometer needs to be very small. (2 marks)

(d) Name **two** common reference points used for thermometer calibration

(2 marks)

(e) What does $20^{o}C$ correspond in the Fahrenheit scale?

(3 marks)

(f) State the basic principle used in employing a bimetallic strip as a switch.

(2 marks)

(g) By simple argument, show that the mean free path λ of a gas molecule can be expressed as $\frac{1}{n\pi r_0^2}$ where n is the number density of molecule and r_0, the effective molecular diameter

(5 marks)

(h) Explain how the heat loss due to conduction, convection and radiation is minimized in a thermos flask.

(4 marks)

(i) State when a thermodynamic process is said to be

(I) Reversible (1 mark)

(II) Irreversible (1 mark)

(j) Sketch the (P - T) phase diagram of water. Label the diagram.

(3 marks)

Question 2 (20 marks)

(a) Explain an isochoric process, hence show that for an isochoric process, the first law of thermodynamics reduces to:

$$Q = \Delta U$$

(4 marks)

(b) Give the four basic postulates of the Kinetic Theory of Gases used to model an Ideal Gas

(6 mks)

(c) Show that the molecular interpretation of temperature provides that the total energy of molecules of a gas is $E = \frac{3}{2}nRT$, where n is the number of molecules per unit volume, R is the universal gas constant and T is the temperature.

(10 mks)

Question 3 (20 marks)

(a) (i) State the factors upon which the change in temperature of a body depends.
(3 marks)

(ii) Calculate the specific heat capacity of copper given that 204.75 J of energy raises the temperature of 15g of copper from 25^o to 60^o.
(3 marks)

(b) Sketch the density-temperature diagram near 0^oC showing clearly the anomalous behavior of water and explain the behavior.
(6 marks)

(c) (i) Show that the thermal coefficient of linear expansion, α, is related to the thermal coefficient of volume expansion, γ by $\gamma \approx 3\alpha$.
(4 marks)

(ii) A glass flask of volume 200 cm^3 is just filled with mercury at 20^oC. How much mercury will overflow when the temperature of the system is raised to 100^oC? The coefficient of volume expansion of glass is 1.2×10^{-5} /C and of mercury is 18×10^{-5} /C.
(4 marks)

Question 4 (20 marks)

(a) Sketch a well-labeled schematic flow diagram of a heat engine
(5 marks)

(b) (i) State the second law of thermodynamics (1 mk)

(ii) State the condition for an engine to have 100% efficiency. (1 mk)

(iii) Explain why a heat engine with 100% efficiency would violate the 2^{nd} law of thermodynamics
(2 mks)

(c) Draw a PV diagram representing a Carnot cycle, hence show that the ideal Carnot efficiency (e_C) can be expressed as:

$$e_C = 1 - \frac{Q_{cold}}{Q_{hot}} = 1 - \frac{T_{cold}}{T_{hot}}$$

where Q_{in} and Q_{out} are heat transfers at constant temperatures T_{hot} and T_{cold} respectively.
(11 mks)