JARAMOGI OGINGA ODINGA UNIVERSITY OF SCIENCE AND TECHNOLOGY

SCHOOL OF BIOLOGICAL AND PHYSICAL SCIENCES

UNIVERSITY EXAMINATION FOR THEDEGREE OF BACHELOR OF EDUCATION(SCIENCE)

1ST YEAR 1ST SEMESTER 2013/2014 ACADEMIC YEAR

MAIN

COURSE CODE: SPH 104

COURSE TITLE: THERMAL PHYSICS

EXAM VENUE: LAB 4 **STREAM: (SBPS)**

DATE: 15/04/14 **EXAM SESSION: 9.00 – 11.00 AM**

TIME: 2.00 HOURS

Instructions:

1. **Answer Question 1 (compulsory) and ANY other 2 questions**
2. **Candidates are advised not to write on the question paper.**
3. **Candidates must hand in their answer booklets to the invigilator while in the examination room.**

Physical constants

Density of water	1000 kg/m^3
Normal atmospheric pressure	1.03×10^5 Pa
Universal gas constant (R)	8.314 J/Mol.K
Thermal conductivity of wood (*k*)	0.08 W/(m.K)
Thermal conductivity of Styrofoam (*k*)	0.01 W/(m.K).
Thermal conductivity of Lead (*k*)	34.7 W/(m.K)
Thermal conductivity of Brass (*k*)	109 W/(m.K)
Boltzmann constant (k)	1.381×10^{-23} $J.K^{-1}$.
Stefan- Boltzmann constant (δ)	5.7×10^{-8} $W.m^{-2}.K^{-4}$
Specific heat of aluminium (c)	900 J/Kg.K
Specific heat capacity of silicon	705 J/ kg.K
Specific heat of water (c)	4200 J/Kg.K
Specific heat of ice (c)	2000 J/Kg.K
Specific latent heat of fusion of ice (L)	3.34×10^5 J/kg

QUESTION ONE (COMPULSORY) (30 MARKS)

(a) At normal atmospheric pressure, the boiling point of hydrogen is 20.3 K. What is the boilingpoint ofhydrogenon the Fahrenheit scale? (2 marks)

(b) State the Zeroth law of thermodynamics. (1 mark)

(c) A cook pours 300 g of hot water at 99^0C into a 230 g aluminium pot initially at $25\,^0$C. If they come to thermal equilibrium quickly, what is the final temperature? Assume no heat is lost to the surroundings. (3 marks)

(d) Explain the meaning of a **black body**. (2 marks)

(e) On the same PV axes, sketch a graph of isothermal, adiabatic and isobaric processes for a constantamount of an ideal gas, all starting at state *a*. (3 marks)

(f) Show that in an isochoric process the change in temperature is proportional to the change in internal energy. (3 marks)

(g) Find the density of air at 20°C and normal atmospheric pressure given that the average molar mass of air is 28.8 g/mol. (3 marks)

(h) Explain why steam causes severe burns than hot water at the same temperature. . (2 marks)

(i) List any **three** assumptions made when stating the kinetic theory of gases. (3 marks)

(j) Explain the difference between free convection and forced convection. (1 mark)

(k) Two grams of water becomes 3342 cm^3 of steam when boiled at a constant normal atmospheric pressure. The heat of vaporization at this pressure is $L_V = 2.26\times10^6$ J/kg. Compute

(i) the work done by the water when it vaporizes (3 marks)

(ii) its increase in internal energy. (4 marks)

QUESTION TWO (20 MARKS)

(a)State the first law of thermodynamics (1 mark)

(b) In a slow, controlled isothermal expansion of 4.0 moles of an ideal gas, the initial volume of the gas is 5.0 L and the final volume is 6.0 L. While the gas expands, heat is suppliedfrom a flame to maintain the temperature at 300 K.

(i) Howmuch work does the gas do during the expansion? (4 marks)

(ii) What is thechange in the internal energy of the gas? (2 marks)

(c) A gas in a heat engine expands from its initial volume V_1 to a final volume $V_2=2V_1$along thepath AB shown in the figure 1.

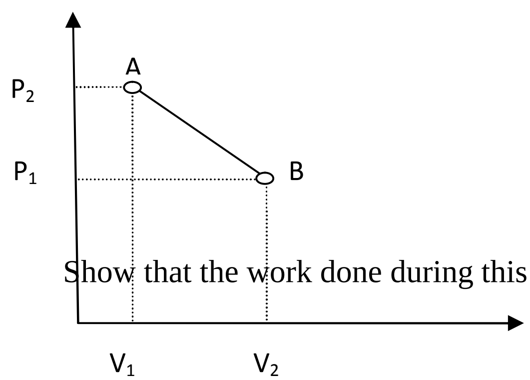

Figure 1

Show that the work done during this process is given by $W = \frac{1}{2}(P_1 + P_2)(V_1)$ (3 marks)

(d) A series of thermodynamic processes is shown in the *pV* diagram of Figure 2. In process *ab*, 150 J of heat are added to the system, and inprocess *bd*, 600 J of heat are added. Find

(i) the internal energy change in process *ab* (2 marks)

(ii) the internal energy change in process *abd*(4 marks)

(iii) the total heat added in process *acd*. (4 marks)

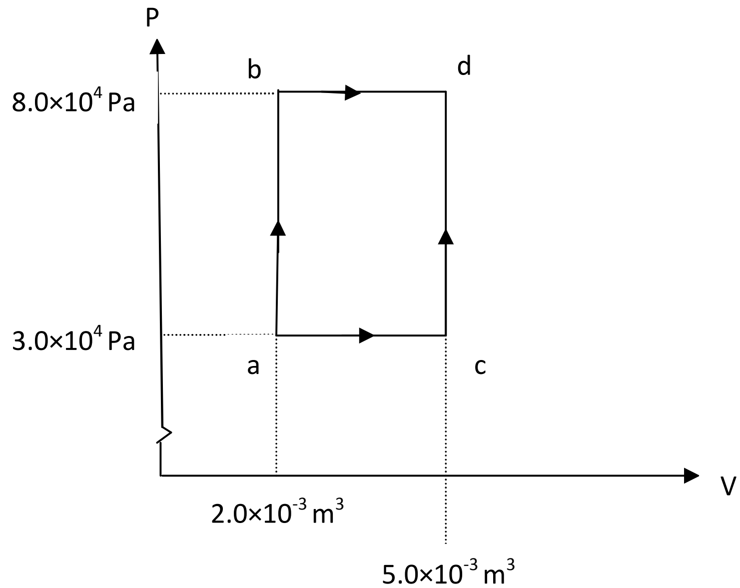

Figure 2

QUESTION THREE (20 MARKS)

(a) State **two** differences between convection and radiation. (2 marks)

(b) A carpenter builds an exterior house wall with a layer of wood 4.0 cm thick on the outside and a layer of Styrofoam insulation 2.0 cm thick on the inside wall surface. The interior surface temperature is 20^oC and the exterior surface temperature is $-10\ ^oC$

(i) What is the temperature at the plane where the wood meets the Styrofoam? (3 marks)

(ii) What is the rate of heat flow per square meter through this wall? (3 marks)

(c) A lead bar 30.0 cm long is welded parallel to a brass bar 40.0 cm long. One end of each bar is placed in contact with steam at $100\ ^oC$ and the other end of each bar contacts ice at $0\ ^oC$. If the area of cross section of each bar is $0.1\ m^2$, what is the *total* rate of heat flow in the two bars? (4 marks)

(d) State Stefan–Boltzmann law (1 mark)

(e) A thin, square brass plate 20 cm on a side is heated in a blacksmith's forge to a temperature of $900\ ^oC$. If the emissivity of brass is 0.5

(i) Find the total rate of radiation of energy from the metal. (3 marks)

(ii) If the surroundings are at a temperature of $25\ ^oC$ what is the *net* rate of heat loss by radiation? (4 marks)

QUESTION FOUR (20 MARKS)

(a) State and explain what happens when steam at 100 ^{o}C is passed through hot water in a beaker at 100 ^{o}C in a room at 100 ^{o}C. (2 marks)

(b) A restaurant serves milk in aluminium mugs.Awaiter fills a cup having a mass of 0.20 kg and initially at 30 ^{o}C with 0.40 kg of milk that is initiallyat 90 ^{o}C. What is the finaltemperature after the milkand the cup attain thermal equilibrium? (Assumethat milk has the same specific heat capacity as water and that there is no heat exchange with thesurroundings.) (4 marks)

c) You are designing an electronic circuit element made of 20 mg of silicon. The electric current through it addsenergy at the rate of 7×10^{-3} W. If your design doesn't allow any heat transfer out of theelement,at what rate does its temperature increase? (4 marks)

d) A container holds 0.55 kg of ice at -15 ^{o}C. The mass ofthe container can be ignored. Heat is supplied to the containerat the constant rate of 800 J/minute for 500 minutes.

(i) After howmany minutes does the ice *start* to melt? (4 marks)

(ii) After how manyminutes, from the time when the heating is first started, doesthe temperature begin to rise above 0 ^{o}C? (4 marks)

(iii) Sketch a curveshowing the temperature as a function of the time elapsed. (2 marks)

QUESTION FIVE (20 MARKS)

(a) If you want to keep 2 moles of an ideal gasin your room at STP, how big a container do you need? (3 marks)

(b) Explain the meaning of the following terms as used in thermal physics

i) Triple Point (2 marks)

ii) Critical Point (2 marks)

(c) A 3.00 L tank contains air at 3.00 atm and 20.0°C. The tankis sealed and cooled until the pressure is 1.00 atm.

(i) What isthe temperature then in degrees Celsius, assuming that the volume of the tank is constant? (3 marks)

(ii) If the temperature is kept at the value found in part (i) and the gas is compressed, what is the volume when the pressure again becomes 3.00 atm? (3 marks)

(d) Show that in an ideal gas, the product of pressure and volume, *PV* is equal to the two thirds of the translational kinetic energy. (7 marks)