KABARAK UNIVERSITY

UNIVERSITY EXAMINATIONS

2010/2011 ACADEMIC YEAR

FOR THE DEGREE OF BACHELOR OF EDUCATION SCIENCE

COURSE CODE: PHYS 121

COURSE TITLE: HEAT AND THERMODYNAMICS

STREAM: SESSION III

DAY: THURSDAY

TIME: 2.00 – 4.00 P.M.

DATE: 14/04/2011

INSTRUCTIONS:

- *Answer Question **ONE** and any other **TWO** Questions. Question One carries **30marks** while each of the other Two Questions carry **20marks**.*
- ***The following constants may be useful***
  - specific heat capacity of water is $4.2\times10^{3}\,JKg^{-1}K^{-1}$
  - specific heat capacity of ice is $5.0\times10^{2}\,JKg^{-1}K^{-1}$
  - Universal gas constant $R=8.31Jmol^{-1}K^{-1}$
  - specific heat capacity of copper, 400J/kg^{0}C
  - specific capacity of aluminum 900J/Kg^{0}C

PLEASE TURN OVER

QUESTION 1 (30 marks)

a) Differentiate between macroscopic and microscopic measure of temperature (2mks)

b) i) Define thermal capacity of a substance (1mk)

ii) The thermal capacity of a substance is $3.2\times10^{4}\,JK^{-1}$, how much heat is released if the temperature changes from $63^{0}C$ to $28^{0}C$ (2mks)

c) i) Explain why latent heat of vaporization has a high value than latent heat of fusion (2mks)

ii) A mass of 32g of ice at $-10^{0}C$ was added to 200g 0f water at $25^{0}C$ in a beaker of negligible heat capacity. When all the ice had melted, the temperature of water was found to be $10^{0}C$. Calculate the specific latent heat of fusion of ice. (4mks)

d) State and explain two factors that affect the rate of evaporation (2mks)

e) The length of air column 35mm at a pressure of $1.6\times10^{3}\,Pa$. What will be the change in length at a pressure of $2.4\times10^{3}\,Pa$? (3mks)

f) A weather balloon of volume $2m^{3}$ contains gas at a pressure of $1.2\times10^{5}\,Pa$ and temperature of $45^{0}C$. What is the mass of the gas in the balloon if one mole of it has a mass of $3.9\times10^{-3}\,Kg$? (3mks)

g) i) State the first law of thermodynamics (1mk)

ii) An ideal gas at pressure of 240kPa is heated so that it expands to $7.5m^{3}$. If the work done during this process is $1.2\times10^{6}\,J$, calculate the initial volume of the gas. (3mks)

h) i) Differentiate between heat engine and heat pump. (2mks)

ii) State two features of heat engines. (2mks)

j) An engine operates at $250^{0}C$ and ejects heat to the surrounding at $25^{0}C$. Find the carnot efficiency. (3mks)

QUESTION 2 (20 marks)

a) Define the following processes (3mks)

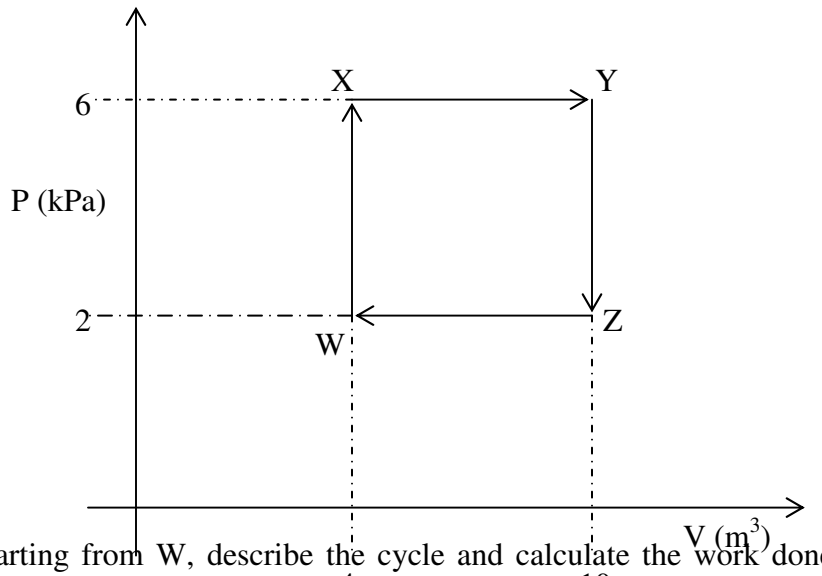
i). Isochoric

ii). Isobaric

iii). Isothermal

b) Using a 75W heater, 16.3g of ice was melted in 2 minutes. The heater was then switched off and in a further 2 minutes, 2.1g of ice melted. Calculate the specific latent heat of fusion of ice from these results. (3mks)

c) A thermal system containing a gas is taken around the cyclic process as shown.



Starting from W, describe the cycle and calculate the work done by the system in the complete one cycle. (4mks)

d) The air is rapidly decreased in the compression stroke of an experimental diesel engine, by a factor of 15. The work done on the air-fuel mixture for this compression is measured to be 550J.

i). What type of thermodynamic process is likely to have occurred? (1mk)
ii). What is the change in internal energy of the air-fuel mixture? (2mks)
iii). How does this process likely to affect the temperature of the system? Explain. (2mks)

e). An engine absorbs 230J of thermal energy from high temperature reservoir, does work and exhausts 140J to a cold reservoir. Calculate its efficiency. (3mks)

f) Using entropy, explain energy degradation. (2mks)

QUESTION 3 (20 marks)

a) Differentiate between the following terms (6mrks)

i). Heat and Work
ii). Closed system and isolated system
iii). Internal energy and entropy

b) A mass of 175g of copper block at 90^0C is dropped into an aluminum calorimeter cup of mass 400g containing 450g of water at 20^0C. What is the final temperature of the system? (5mrks)

c) Show that work done by expansion of a gas in a pump at constant pressure is given by

$$W = P(V_2 - V_1)$$ (4mks)

d) i) State two assumptions of isothermal process. (2mks)

ii) A cylinder piston contains $0.25m^3$ of ideal gas at 70^0C. The gas expands isothermally to $0.6m^3$. Determine the work done during this process. (3mks)

QUESTION 4 (20 marks)

a) The thread in a liquid in glass thermometer is 2cm at lower fixed point and 22cm at upper fixed point. Calculate the temperature when the thread is 8cm. (4mks)

b) In an experiment to determine the specific heat of some metal, a student weighed the following and recorded her data results as shown below;

- Weight of aluminium calorimeter = 36g
- Weight of aluminium calorimeter + water = 70g
- Weight of aluminium calorimeter + water + metal = 80g
- Initial temperature of water was 22^0C.

The metal was heated in a test tube with water till water boiled at 98^0C. The metal was then transferred to calorimeter and stirred. The temperature then changed to 34^0C.

i). State two precautions the student should take to ensure an accurate results (2mks)

ii). Calculate the specific heat capacity of the metal from these measurements. (6mks)

c) State Zeroth law of thermodynamics. (1mk)

d) Differentiate between positive and negative work. (2mks)

e) i) State two conditions for adiabatic process. (2mks)

ii) Differentiate between adiabatic expansion and adiabatic compression. (3mks)

QUESTION 5 (20 marks)

a) i) State two things required to make heat engines. (2mks)

ii) Sketch energy flow diagram of a heat pump. (3mks)

b) i) What is carnot engine? (1mk)

ii) Sketch a labeled PV-diagram of a carnot engine. (3mks)

c) i) State Kelvin-Planck formulation of the second law of thermodynamics. (1mk)

ii) A heat engine removes 150J each cycle from a heat reservoir at $127^0 C$ and exhausts 75J of thermal energy to a reservoir at $37^0 C$. Compute the change of entropy for each reservoir. (4mks)

d) i) A column of air 25cm long is trapped by a mercury column 10cm long in a horizontal tube. When the tube is turned upside down, the length of air column becomes 30cm. Calculate the value of atmospheric pressure at the place. (3mks)

ii) A vertical cylinder has a well fitting piston in it. Weights can be added or removed from a tray on top of the piston. The initial pressure of the trapped air is $1.05 \times 10^5 Pa$. When the weights are added, the volume of the air decreases from $860 cm^3$ to $645 cm^3$. If the area of the piston is $5.0 \times 10^{-3} m^2$, calculate the weight added to the piston. (3mks)