University of Ruhuna - Faculty of Technology

Bachelor of Biosystems Technology

Level 1 (Semester 1) Examination, October 2019

Course Unit : BST 1181 Thermodynamics

Time Allowed: 2 hours

*** Answer all four (04) questions** **All symbols have their usual meanings**

1. Answer both parts of the question

(a) Answer following questions about definitions in Thermodynamics

I. Draw a simple sketch to illustrate the definitions of following terms in Thermodynamics. (10 marks)

(i) System
(ii) Surroundings
(iii) Boundary
(iv) Universe

II. Provide two examples for each of following. (05 ×3 marks)

(i) Closed system
(ii) Open system
(iii) Isolated system

III. An ideal gas is filled in a balloon.

(i) What are the parameters should be measured to determine the state of above system? (15 marks)
(ii) Suggest a method to change the state of above system? (05 marks)

IV. Provide an example for each of following. (05× 2 marks)

(i) State functions
(ii) Path functions

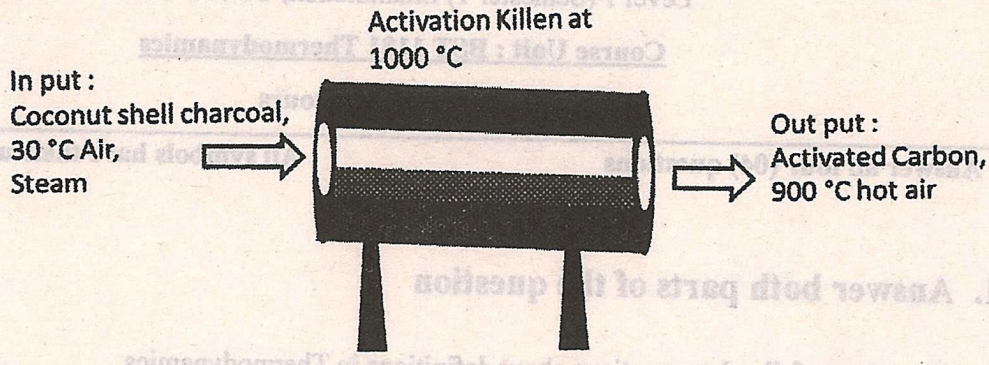
V. Select the intensive properties out of following. (15 marks)

(i) Temperature
(ii) Heat capacity
(iii) Density
(iv) Boiling point
(v) Weight

Vii. Provide two examples for each of following. (10 marks)

(i) Kinetic energy
(ii) Potential energy

(b) Sri Lanka is the country manufactured world best activated carbon using coconut shells. Schematic illustration of activated carbon manufacturing process is given in the following figure. Answer following questions regarding the activated carbon manufacturing process.



I. State that the activation Killen is an open system or closed system, giving reasons. (05 marks)

II. Suggest a suitable method to increase the energy efficiency of activated carbon manufacturing process. (15 marks)

2. Answer following questions about first law of Thermodynamics.

I. Write down the First law of thermodynamics. (10 marks)

II. An ideal gas is filled in isolated system. A work of 1 kJ is done on the system using a paddle wheel. Calculate the amount of the change of internal energy of this process? (10 marks)

III. An ideal gas is filled in a system at pressure of 10^5 Pa. The initial volume of the system is 3 m^3. The system undergoes reversible isobaric expansion until the final volume becomes 13 m^3.

(i) Sketch the PV diagram of the above thermodynamic process. (P: pressure, V; volume)

(ii) Calculate the work done by the system. (20 marks)

IV. A sample of 40.0000 g of $He_{(g)}$ is kept at 27 °C. The initial volume of the system is 3.0 m^3. The system is reversibly isothermally compressed until the final volume becomes 0.3 m^3.

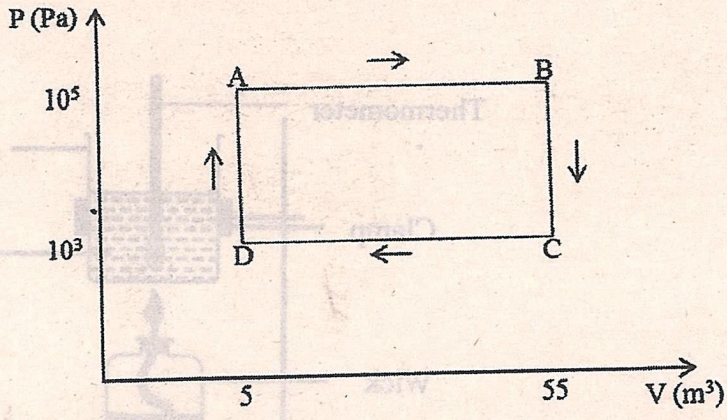
(i) Sketch the PV diagram of the above thermodynamic process.

(ii) Calculate the number of mols of $He_{(g)}$ in the system.

(iii) Calculate the work done by the system.

(iv) Calculate the amount of heat transferred to the system. (40 marks)

V. A cyclic process is carried out on an ideal gas. The PV diagram of the process is given below.



(i) Identify the isochoric steps of the above cyclic process.

(ii) Calculate the work done by the system in above cyclic process.

(20 marks)

Note:

$$\Delta W = P\Delta V$$

$$\Delta W = nRT\ 2.303 \log \left(\frac{V2}{V1}\right)$$

$$R = 8.314\ J\ mol^{-1}K^{-1}$$

3. Answer all parts

(a) Answer following questions regarding enthalpy.

I. State the relationship between Enthalpy and Heat of a reaction. (10 marks)

II. What are the standard conditions for Enthalpy measurements (ΔH°) ? (10 marks)

III. Name the Enthalpy changes indicated by following reactions. (20 marks)

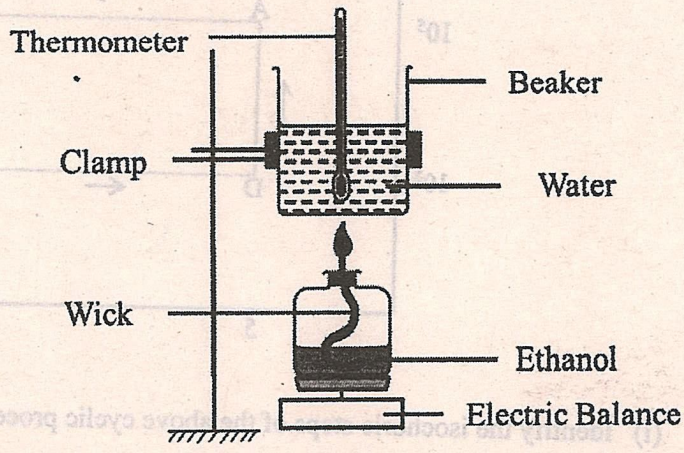
(i) $C_{(s)} + 2H_{2(g)} \longrightarrow CH_{4(g)}$

(ii) $\frac{1}{2}N_{2\,(s)} + \frac{3}{2}H_{2(g)} \longrightarrow NH_{3(g)}$

(iii) $CH_3COOH_{(s)} \longrightarrow CH_3COO^-_{(aq)} + H^+_{(aq)}$

(iv) $\frac{1}{2}H_2SO_{4(aq)} + NaOH_{(aq)} \longrightarrow \frac{1}{2}Na_2SO_{4(aq)} + H_2O_{(l)}$

(b) An experiment set up to determine the combustion enthalpy of Ethanol ($C_2H_6O_{(l)}$) is shown in the figure below. The student poured 100.0 mL of water at 25 °C into the beaker and lit the Ethanol lamp. Student continued heating until 0.0460 g of Ethanol is combusted. The highest temperature of water was 28 °C. (Specific heat capacity of water is 4200 J kg^{-1} mol^{-1}.)



I. Write down the balanced chemical reaction for the combustion of ethanol. (10 marks)

II. Calculate the number of mols of ethanol burnt during the combustion. (05 marks)

III. Calculate the amount of heat released by the combustion. (Assume that all of the heat released by the reaction is completely used to heat up water in the beaker.) (10 marks)

IV. Calculate the Enthalpy of Combustion ($\Delta H_c°$) of ethanol. (05 marks)

V. Calculate the standard Enthalpy of Formation ($\Delta H_f°$) of ethanol using the information given below. (20 marks)

Substance	Formation Enthalpy ($\Delta H_f°$)/ KJ mol^{-1}
$CO_{2(g)}$	–394
$H_2O_{(l)}$	–286

(c) Briefly explain following thermodynamic terms

I. Endothermic reaction (05 marks)

II. Exergonic reaction (05 marks)

4. Answer both parts of the question.

Answer following questions about Enthalpy, Entropy, and Gibbs free energy.

I. Briefly explain the term "Entropy" giving a suitable example/s. (20 marks)

II. Provide two (02) examples for entropy increasing events. (20 marks)

III. Zinc (Zn) is very important metal for the production of galvanized steel. Chemical reaction relating to Zinc production is given below.

$$ZnO_{(s)} + C_{(s)} \xrightarrow{\Delta} Zn_{(s)} + CO_{(g)}$$

(60 marks)

	Substance	Formation Enthalpy ($\Delta H_f°$)/ KJ mol^{-1}	Entropy ($\Delta S°$)/ J K^{-1} mol^{-1}
Reactants	$ZnO_{(s)}$	–348	44
	$C_{(s)}$	0	6
Products	$CO_{(g)}$	–99	198
	$Zn_{(s)}$	0	46

(i) Calculate the standard Enthalpy change ($\Delta H°$) of the reaction at 298 K.

(ii) Calculate the standard Entropy change ($\Delta S°$) of the reaction at 298 K.

(iii) Calculate the standard Gibbs free energy ($\Delta G°$) of the reaction at 298 K.

(iv) Calculate the minimum temperature required to occur the chemical reaction spontaneously.

Note : $\Delta G = \Delta H - T\Delta S$

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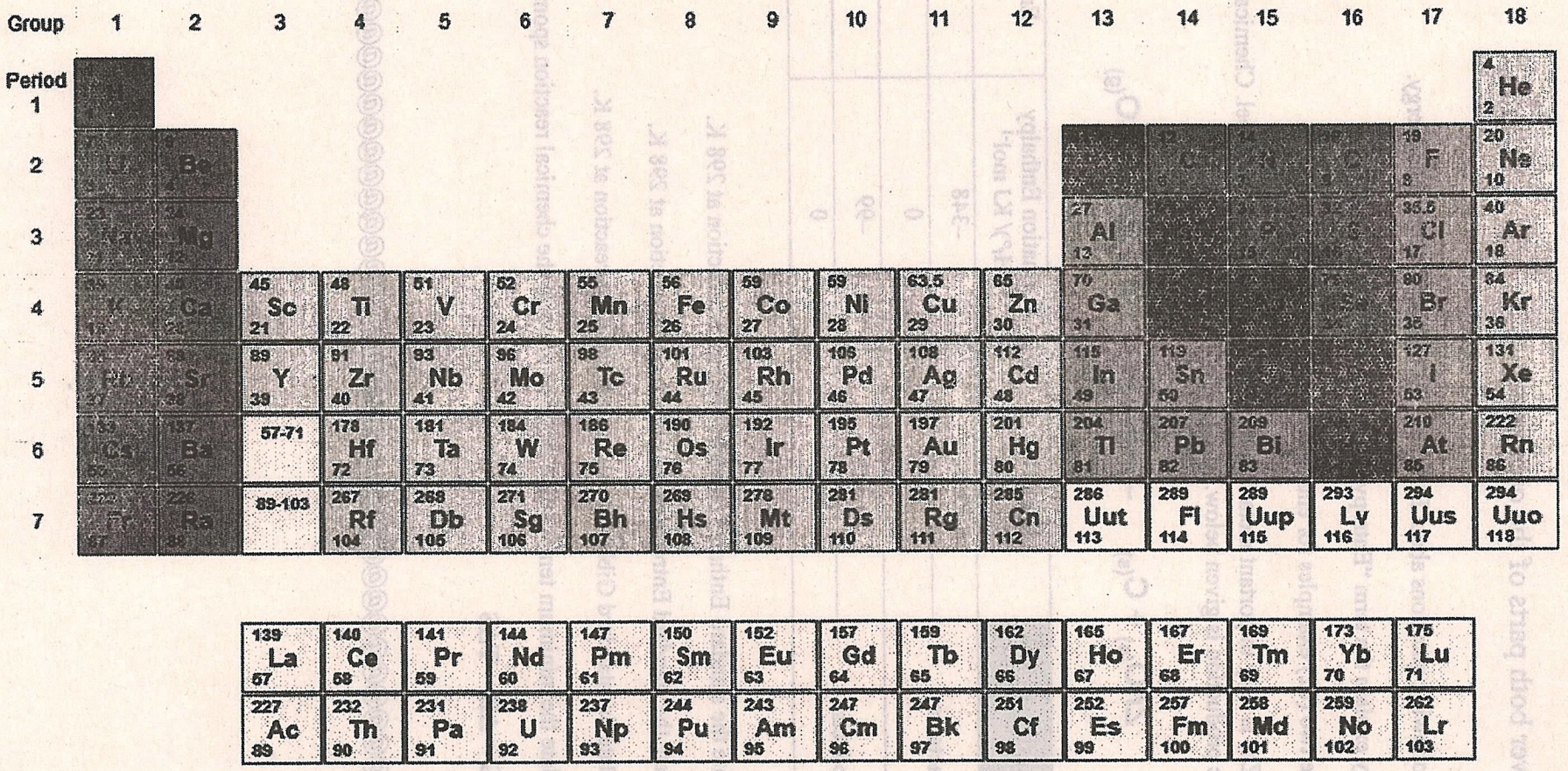
Group 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
Period
1
2
3
4
5
6
7
4 He 2
F 9
20 Ne 10
27 Al 13
35.5 Cl 17
40 Ar 18
45 Sc 21
48 Ti 22
51 V 23
52 Cr 24
55 Mn 25
56 Fe 26
59 Co 27
59 Ni 28
63.5 Cu 29
65 Zn 30
70 Ga 31
80 Br 35
84 Kr 36
89 Y 39
91 Zr 40
93 Nb 41
96 Mo 42
98 Tc 43
101 Ru 44
103 Rh 45
106 Pd 46
108 Ag 47
112 Cd 48
115 In 49
119 Sn 50
127 I 53
131 Xe 54
57-71
178 Hf 72
181 Ta 73
184 W 74
186 Re 75
190 Os 76
192 Ir 77
195 Pt 78
197 Au 79
201 Hg 80
204 Tl 81
207 Pb 82
209 Bi 83
210 At 85
222 Rn 86
89-103
267 Rf 104
268 Db 105
271 Sg 106
270 Bh 107
269 Hs 108
278 Mt 109
281 Ds 110
281 Rg 111
285 Cn 112
286 Uut 113
289 Fl 114
289 Uup 115
293 Lv 116
294 Uus 117
294 Uuo 118
139 La 57
140 Ce 58
141 Pr 59
144 Nd 60
147 Pm 61
150 Sm 62
152 Eu 63
157 Gd 64
159 Tb 65
162 Dy 66
165 Ho 67
167 Er 68
169 Tm 69
173 Yb 70
175 Lu 71
227 Ac 89
232 Th 90
231 Pa 91
238 U 92
237 Np 93
244 Pu 94
243 Am 95
247 Cm 96
247 Bk 97
251 Cf 98
252 Es 99
257 Fm 100
258 Md 101
259 No 102
262 Lr 103