SULIT

POLITEKNIK MALAYSIA

BAHAGIAN PEPERIKSAAN DAN PENILAIAN
JABATAN PENDIDIKAN POLITEKNIK DAN KOLEJ KOMUNITI
KEMENTERIAN PENGAJIAN TINGGI

JABATAN KEJURUTERAAN PETROKIMIA

PEPERIKSAAN AKHIR

SESI I : 2022/2023

DGP20053 : THERMODYNAMICS

TARIKH : 20 DISEMBER 2022
MASA : 2.30 PETANG – 4.30 PETANG (2 JAM)

Kertas ini mengandungi **ENAM (6)** halaman bercetak.

Struktur (4 soalan)

Dokumen sokongan yang disertakan : Buku Jadual Stim dan Formula

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JANGAN BUKA KERTAS SOALAN INI SEHINGGA DIARAHKAN

(CLO yang tertera hanya sebagai rujukan)

SULIT

INSTRUCTION:

This section consists of **FOUR (4)** structured questions. Answer **ALL** questions.

ARAHAN:

*Bahagian ini mengandungi **EMPAT (4)** soalan struktur. Jawab **SEMUA** soalan.*

QUESTION 1

SOALAN 1

CLO1
C1

(a) Define boundary, surrounding and system in thermodynamics.

Berikan definisi bagi sempadan, persekitaran dan sistem dalam termodinamik.

[6 marks]
[*6 markah*]

CLO1
C2

(b) The density of water at room temperature and atmospheric pressure is 1.0 g/cm^3. Convert this to kg/m^3 and express the specific volume of water.

Ketumpatan air pada suhu bilik dan tekanan atmosfera ialah 1.0g/cm^3. Tukarkan unit ini kepada kg/m^3 dan nyatakan isipadu tentu air tersebut.

[7 marks]
[*7 markah*]

CLO1
C3

(c) A mass of 0.5 kg perfect gas at a temperature of 37 °C and pressure of 3.5 bar, occupied the volume of 0.0984 m^3. Calculate the gas constant, R and molecular weight of the gas, M.

Suatu gas sempurna berjisim 0.5 kg pada suhu 37 °C dengan tekanan 3.5 bar. Gas tersebut memenuhi ruang dengan isipadu 0.0984 m^3. Kirakan pemalar gas, R dan berat molekul gas, M.

[12 marks]
[*12 markah*]

QUESTION 2
SOALAN 2

CLO1
C1

(a) Describe the difference between a steady flow and an unsteady flow in terms of definition and **ONE (1)** example for each of them.
*Nyatakan perbezaan antara aliran sekata dan aliran tak sekata dari segi definisi dan **SATU (1)** contoh untuk setiap satunya.*

[4 marks]
[*4 markah*]

CLO1
C2

(b) The non-flow process and the flow process are two important types of systems in the First Law of Thermodynamics.

i. Explain the difference between the non-flow process and the flow process in thermodynamics.
Terangkan perbezaan antara proses tak alir dan proses alir dalam termodinamik.

[4 marks]
[*4 markah*]

ii. Simplify the equation of the even flow energy of turbines when some assumptions are taken into account.
Permudahkan persamaan tenaga aliran turbin apabila beberapa andaian diambil kira.

[2 marks]
[*2 markah*]

CLO1
C3

(c) 0.055 kg of carbon dioxide gas at a pressure of 1.03 bar occupies a volume of 0.035 m^3. The gas is compressed reversibly according to a law $PV^{1.4}$ = constants until the pressure is 6.5 bar. Assume carbon dioxide to be a perfect gas and calculate the final temperature and work done on the gas.
0.055 kg gas karbon dioksida pada tekanan 1.03 bar dan isipadu sebanyak 0.035 m^3. Gas dimampatkan secara berbalik menurut hukum $PV^{1.4}$ = pemalar. sehingga tekanan adalah 6.5 bar. Anggapkan gas sempurna dan kirakan suhu akhir dan kerja yang dilakukan pada gas.

[15 marks]
[*15 markah*]

QUESTION 3

SOALAN 3

CLO1
C3

(a) Based on Steady Flow Energy Equation, state down the full equation and **TWO (2)** related engineering devices.

*Berdasarkan Persamaan Tenaga Aliran Mantap, nyatakan persamaan penuhnya dan **DUA (2)** peralatan kejuruteraan yang berkaitan*

[4 marks]
[*4 markah*]

CLO1
C1

(b) Relate the assumptions made for the following equipment when the steady state energy equation is applied for boiler and pump.

Kaitkan andaian yang dibuat terhadap peralatan berikut apabila persamaan tenaga keadaan mantap diaplikasikan untuk dandang dan pam.

[8 marks]
[*8 markah*]

CLO1
C2

(c) Air at 101.325 kPa, 20°C is taken into a gas turbine power plant at a velocity of 140m/s through an opening of 0.15m^2 cross-sectional area. The air is compressed, expanded through a turbine, and exhausted at 0.18MPa, 150°C through an opening of 0.10m^2 cross-sectional area. The power output is 375kW. Calculate the net amount of heat added to the air in kJ/kg. Assume that the air obey the law $PV = 0.287(T+273)$ where P is the pressure in kPa, v is the specific volume in m^3/kg and T is the temperature in °C. **Take C_P = 1.005 kJ/kg K.**

Udara pada 101.325 kPa, 20°C dibawa ke loji janakuasa turbin gas pada halaju 140m/s melalui pembukaan kawasan keratan rentas 0.15m^2. Udara dimampatkan, berkembang melalui turbin, dan keluar pada 0.18MPa, 150°C melalui pembukaan kawasan keratan rentas 0.10m^2. Output kuasa adalah 375kW. Kirakan jumlah bersih haba yang ditambah ke udara dalam kJ / kg. Anggapkan bahawa udara mematuhi hukum PV = 0.287 (T + 273) di mana P ialah tekanan dalam kPa, v ialah isipadu tertentu dalam m^3/kg dan T ialah suhu dalam °C. ***Ambil C_p = 1.005 kJ / kg K.***

[13 marks]
[*13 markah*]

QUESTION 4

SOALAN 4

CLO1
C3

(a) A steam plant operates in a Rankine cycle with the condenser pressure of 0.1 bars. This plant has a ratio of 85.6% of the work and the amount of work produced by the turbine is 935 kJ/kg. From the condition, calculate the pressure in bar at the inlet to the turbine where the steam entering the turbine in the dry saturated state.

Loji stim beroperasi dalam kitaran Rankine dengan tekanan kondenser 0.1 bar. Loji ini mempunyai nisbah 85.6% daripada kerja dan jumlah kerja yang dihasilkan oleh turbin adalah 935 kJ/kg. Dari keadaan tersebut; kirakan tekanan dalam bar di salur masuk turbin dimana stim memasuki turbin dalam keadaan tepu kering.

[15 marks]

[*15 markah*]

CLO1
C2

(b) By considering the following reaction,

$$H_2(g) + Cl_2(g) \rightarrow HCl(g)$$

and from thermodynamic data given in Table 4(b), the value of the standard free energy of formation $\Delta G°_f$ is as follows:

Dengan mempertimbangkan tindak balas berikut,

$$H_2(g) + Cl_2(g) \rightarrow HCl(g)$$

dan daripada data termodinamik yang diberikan dalam Jadual 4(b), nilai tenaga pembentukan $\Delta G°_f$ piawai adalah seperti berikut:

Composition *Komposisi*	$\Delta G°_f$ kJ/mol At 298K
HCl	–95.27
H_2	0
Cl_2	0

Table 4(b) / *Jadual 4(b)*

i. Balance the chemical equation given.

Imbangkan persamaan kimia yang diberikan.

[2 marks]

[*2 markah*]

ii. Calculate the standard Gibbs free energy change for the reaction given.

Kirakan perubahan tenaga bebas Gibbs bagi tindakbalas yang diberikan.

[6 marks]

[*6 markah*]

iii. State whether the reaction is spontaneous or not

Nyatakan sama ada tindakbalas adalah spontan atau tidak.

[2 marks]

[*2 markah*]

SOALAN TAMAT

LIST OF FORMULAS DGP20053 THERMODYNAMICS

PROPERTIES OF SUBSTANCES

1. **STEAM**

$v = xv_g$	$u = u_f + x(u_g - u_f)$
$h = h_f + xh_{fg}$	$s = s_f + xs_{fg}$
$h = u + Pv$	

2. **IDEAL GAS**

$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$	$R = \frac{R_o}{M}$	$\gamma = \frac{C_P}{C_V}$
$PV = mRT$	$R = C_p - C_v$	m = nM
$C_v = \frac{R}{(\gamma - 1)}$	$C_p = \frac{\gamma R}{(\gamma - 1)}$	

1ST LAW OF THERMODYNAMICS

1. NON-FLOW PROCESS : REVERSIBLE PROCESS STEAM

CONSTANT ISOTHERMAL PROCESS ($T_1 = T_2$)	$Q = T(s_2 - s_1)$ $\quad W = Q - (u_2 - u_1)$
CONSTANT VOLUME PROCESS ($V_1 = V_2$)	$Q = (u_2 - u_1)$ $\quad W = 0$
CONSTANT PRESSURE PROCESS ($P_1 = P_2$)	$Q = (u_2 - u_1) + P(v_2 - v_1)$ $\quad Q = h_2 - h_1$ $Q = (u_2 + Pv_2) - (u_1 + Pv_1)$ $\quad W = P(v_2 - v_1)$
ADIABATIC (ISENTROPIC) PROCESS	$S_1 = S_2$ $\quad Q = 0$ $\quad W = u_1 - u_2$
POLYTROPIC PROCESS	$W = \frac{p_1v_1 - p_2v_2}{n-1}$ $\quad \frac{p_1}{p_2} = \left(\frac{v_2}{v_1}\right)^n$; $\frac{v_2}{v_1} = \left(\frac{p_1}{p_2}\right)^{\frac{1}{n}}$ $Q = (u_2 - u_1) + W$ $\quad \frac{T_2}{T_1} = \left(\frac{p_2}{p_1}\right)^{\frac{n-1}{n}}$; $\frac{T_2}{T_1} = \left(\frac{v_1}{v_2}\right)^{n-1}$

2. NON-FLOW PROCESS: REVERSIBLE PROCESS FOR IDEAL GAS

CONSTANT ISOTHERMAL PROCESS ($T_1 = T_2$)	$W = p_1V_1 \ln\frac{V_2}{V_1}$ $\quad W = p_1V_1 \ln\frac{p_1}{p_2}$ $W = mRT_1 \ln\frac{V_2}{V_1}$ $\quad W = mRT_1 \ln\frac{P_1}{P_2}$ $Q = W$ $\quad U_1 = U_2$ $S_2 - S_1 = mR \ln\left(\frac{v_2}{v_1}\right) = mR \ln\left(\frac{p_1}{p_2}\right)$
CONSTANT VOLUME PROCESS ($V_1 = V_2$)	$W = 0$ $\quad Q = mC_v(T_2 - T_1)$ $Q = U_2 - U_1$ $\quad S_2 - S_1 = mC_v \ln\left(\frac{T_2}{T_1}\right)$
CONSTANT PRESSURE PROCESS ($P_1 = P_2$)	$W = p(V_2 - V_1)$ $\quad W = mR(T_2 - T_1)$ $Q = mC_p(T_2 - T_1)$ $\quad U_2 - U_1 = Q - W$ $U_2 - U_1 = mC_v(T_2 - T_1)$ $\quad S_2 - S_1 = mC_p \ln\left(\frac{T_2}{T_1}\right)$

ADIABATIC (ISENTROPIC)PROCESS	$W = \frac{p_1V_1 - p_2V_2}{\gamma - 1}$ $\quad W = \frac{mR(T_1 - T_2)}{\gamma - 1}$ $W = mC_v(T_1 - T_2)$ $\quad Q = 0$ $U_2 - U_1 = mC_v(T_2 - T_1)$ $\quad S_2 - S_1 = 0$ $\frac{T_2}{T_1} = \left[\frac{p_2}{p_1}\right]^{\frac{\gamma-1}{\gamma}} = \left[\frac{V_1}{V_2}\right]^{\gamma-1}$
POLYTROPIC PROCESS	$S_2 - S_1 = R\ln\left(\frac{v_2}{v_1}\right) - C_v \ln\left(\frac{T_1}{T_2}\right)$ $S_2 - S_1 = mR\ln\left(\frac{p_1}{p_2}\right) - mC_p \ln\left(\frac{T_1}{T_2}\right)$ $\frac{T_2}{T_1} = \left[\frac{p_2}{p_1}\right]^{\frac{n-1}{n}} = \left[\frac{V_1}{V_2}\right]^{n-1}$ $\quad W = \frac{P_1V_1 - P_2V_2}{n-1}$ $U_2 - U_1 = mC_v(T_2 - T_1)$ $\quad W = \frac{mR(T_1 - T_2)}{n-1}$ $Q = W + U_2 - U_1$

3. FLOW PROCESS

STEADY FLOW ENERGY EQUATION • $Q - W = \dot{m}\left[(h_2 - h_1) + \left(\frac{C_2^2 - C_1^2}{2}\right) + g(Z_2 - Z_1)\right]$ • $h_2 - h_1 = (U_2 - U_1) + (P_2v_2 - P_1v_1) = C_p(T_2 - T_1)$ • $\dot{m} = \frac{CA}{v}$

2ND LAW OF THERMODYNAMICS

HEAT ENGINE / PUMP ENGINE $W = Q_1 - Q_2$ $\quad \eta = \frac{W}{Q_1}$
CARNOT CYCLE ENGINE $\eta = 1 - \frac{Q_2}{Q_1}$ $\quad \eta_{carnot} = 1 - \frac{T_2}{T_1}$ $\quad \eta_{Carnot} = \frac{(h_1 - h_2) - (h_4 - h_3)}{h_1 - h_4}$ $r_w = \frac{(h_1 - h_2) - (h_4 - h_3)}{(h_1 - h_2)}$ $\quad s.s.c. = \frac{3600}{(h_1 - h_2) - (h_4 - h_3)}$ kg/kwh

CHEMICAL EQUILLIBRIUM

$$\Delta S = Q_p (S_P - S_A)$$

$$\Delta G = \Delta G^O + RT \ln K$$

$$\frac{d(\ln K)}{dT} = \frac{\Delta H}{RT^2}$$