SULIT

KEMENTERIAN PENDIDIKAN TINGGI
JABATAN PENDIDIKAN POLITEKNIK DAN KOLEJ KOMUNITI

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

JABATAN KEJURUTERAAN PETROKIMIA

PEPERIKSAAN AKHIR

SESI I : 2023/2024

DGP20053 : THERMODYNAMICS

TARIKH : 30 DISEMBER 2023
MASA : 8.30 PAGI – 10.30 PAGI (2 JAM)

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

Struktur (4 soalan)

Dokumen sokongan yang disertakan : Formula, Buku Stim

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 berstruktur. Jawab semua soalan.*

QUESTION 1
SOALAN 1

CLO1

a) Give the definition of the following terms:
Berikan definisi bagi istilah berikut:

i. State / *Keadaan*

[2 marks]
[*2 markah*]

ii. Process / *Proses*

[2 marks]
[*2 markah*]

CLO1

b) Steam at 100 bar has a specific enthalpy of 2300 kJ/kg . By using the steam table,
Stim pada 100 bar mempunyai entalpi tentu 2300 kJ/kg. Dengan menggunakan jadual stim,

i. calculate the dryness fraction, and specific internal energy.
kirakan pecahan kekeringan dan tenaga dalaman tentu.

[5 marks]
[*5 markah*]

ii. interpolate the specific enthalpy if the steam is heated until the temperature is increased to T=475°C at P=100 bar.
interpolasi entalpi tentu jika stim dipanaskan sehingga suhu meningkat kepada T=475°C dan P=100 bar.

[4 marks]
[*4 markah*]

CLO1 c) 0.55 kg of perfect gas is in a container of $0.10m^3$ with the pressure of 4 bar. It is then cooled to pressure of 1.2 bar. The molecular weight of the gas is 44.01 kg/kmol. If the temperature remains constant, calculate the initial temperature and final volume of the gas.

0.55 kg gas unggul dalam bekas berisipadu $0.10m^3$ dan tekanan 4 bar. Ia kemudian disejukkan ke tekanan 1.2 bar. Berat molekul gas ialah 44.01 kg/kmol. Jika suhu kekal malar, hitung suhu awal dan isipadu akhir bagi gas.

[12 marks]
[*12 markah*]

QUESTION 2

SOALAN 2

CLO1 a) Figure 2(a) shows the gas or steam turbine. Based on the figure shown below,
Rajah 2(a) menunjukkan turbin stim atau gas. Berdasarkan rajah yang ditunjukkan di bawah,

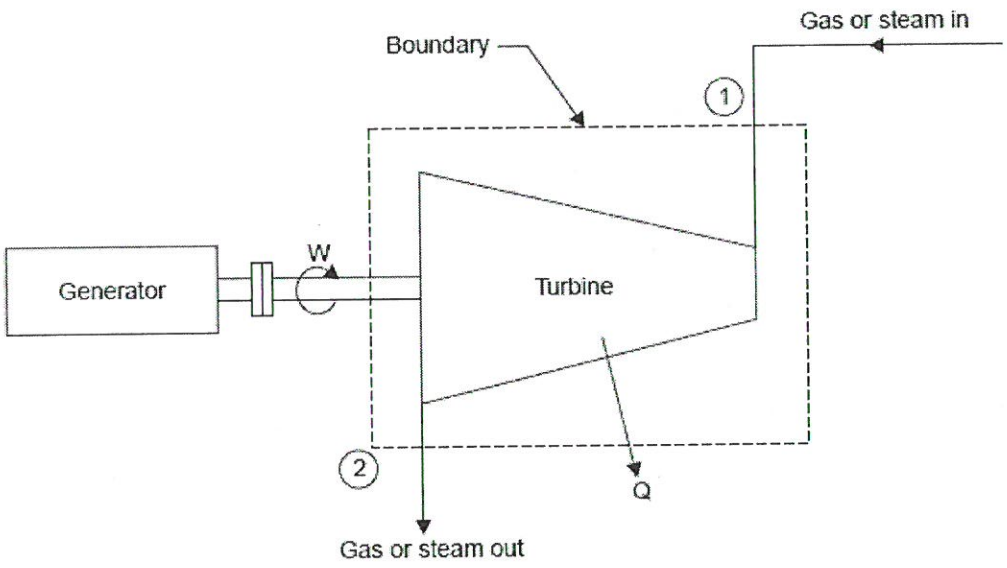

Figure 2(a)/*Rajah 2(a)*

i. explain briefly the working principle of a turbine.
terangkan secara ringkas prinsip kerja bagi turbin.

[3 marks]
[*3 markah*]

ii. simplify the steady flow energy equation when applied to steam or gas turbines.

permudahkan persamaan tenaga aliran mantap apabila diaplikasikan kepada turbin stim atau gas.

[3 marks]

[*3 markah*]

CLO1

b) A horizontal axial compressor provides a steady flow of air. The air enters the compressor at a velocity of 5 m/s, a temperature of 15°C and a pressure of 0.1MPa. The air leaves the compressor at a velocity of 85 m/s and a temperature of 115°C. The outer surface of the compressor is exposed to the atmosphere and as a result, there is a heat loss of 6 kJ/kg to air as it passes through the compressor. The mass flow rate is 240 kg/min. [Take R = 0.287kJ/kgK and Cp=1.005 kJ/kgK]. Calculate:

Pemampat paksi mendatar menyediakan aliran udara yang mantap. Udara memasuki pemampat pada halaju 5 m/s, suhu 15°C dan tekanan 0.1MPa. Udara meninggalkan pemampat pada halaju 85 m/s dan suhu 115°C. Permukaan luar pemampat terdedah kepada atmosfera dan akibatnya, terdapat kehilangan haba sebanyak 6 kJ/kg ke udara semasa melalui pemampat. Kadar aliran jisim ialah 240 kg/min. [Gunakan R = 0.287kJ/kgK dan Cp=1.005 kJ/kgK]. Kirakan:

i. The work done per kg of air.

Kerja yang dilakukan per kg udara.

[12 marks]

[12 *markah]*

ii. The air density and cross-sectional flow area of the entry pipe.

Ketumpatan udara dan luas keratan rentas aliran paip masuk.

[7 marks]

[7 *markah*]

QUESTION 3

SOALAN 3

CLO1 a) Describe the following terms:

Huraikan terma-terma berikut:

i. Heat / *Haba*

[3 marks]

[*3 markah*]

ii. Work

Kerja

[3 marks]

[*3 markah*]

CLO1 b) 1 kg of gaseous CO_2 contained in a closed system undergoes a reversible process at constant pressure. During this process, 42 kJ of internal energy is decreased. Calculate the work done during the process. Take Cp = 840 J/kg°C and Cv = 600 J/kg°C.

1 kg gas CO_2 yang terkandung dalam sistem tertutup mengalami proses boleh balik pada tekanan malar. Semasa proses ini, 42 kJ tenaga dalaman berkurangan. Kira kerja yang dilakukan semasa proses. Ambil Cp = 840 J/kg°C dan Cv = 600 J/kg°C.

[11 marks]

[*11 markah*]

CLO1 c) A steam power plant operates between a boiler pressure of 40 bar and a condenser pressure of 0.04 bar. If the entry to the turbine is with dry saturated steam, calculate the feed pump work and thermal efficiency for a Carnot cycle.

Sebuah loji kuasa stim beroperasi antara tekanan dandang 40 bar dan tekanan pemeluwap 0.04 bar. Jika kemasukan ke turbin ialah dengan stim tepu kering, kirakan kerja pam suapan dan kecekapan terma bagi kitaran Carnot.

[8 marks]

[*8 markah*]

QUESTION 4
SOALAN 4

CLO1 a) A steam power plant for Rankine cycle operates between boiler pressure 32 bar and a condenser pressure 0.03 bar. If the cycle efficiency is 42.5% meanwhile the calculated feed pump and turbine work are 3.197 kJ/kg and 888.1 kJ/kg, respectively, calculate heat supplied to the boiler, the work ratio and the specific steam consumption (s.s.c).

Sebuah loji kuasa stim dalam kitaran Rankine beroperasi antara tekanan dandang 32 bar dan tekanan pemeluwap 0.03 bar. Jika kecekapan kitaran ialah 42.5% manakala pam suapan dan kerja turbin yang dikira masing-masing ialah 3.197 kJ/kg dan 888.1 kJ/kg, hitungkan haba yang dibekalkan kepada dandang, nisbah kerja dan penggunaan stim tentu (s.s.c).

[15 marks]
[15 *markah*]

CLO1 b) Consider the following reaction:

Pertimbangkan tindak balas berikut:

$$N_2O\ (g) + O_2\ (g) \rightarrow NO_2\ (g) \quad \Delta H^o = -31.6\ kJ/mol$$

The absolute entropy values, S, at 298K for $N_2O(g)$, O_2 (g) and NO_2 (g) are 220.0, 205.2 and 240.1 J/Kmol respectively.

Nilai entropi mutlak, S, pada 298K untuk $N_2O(g)$, O_2 (g) dan NO_2 (g) masing-masing ialah 220.0, 205.2 dan 240.1 J/Kmol.

i. Balance the chemical equation given. [2 marks]
Imbangkan persamaan kimia yang diberikan. [2 *markah*]

ii. Calculate ΔG^o for the reaction at 298K. [6 marks]
Hitungkan ΔG^o untuk tindak balas pada 298K. [6 *markah*]

iii. Show whether or not the reaction is spontaneous. [2 marks]
Tunjukkan sama ada tindak balas tersebut spontan atau tidak. [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

$W = Q_1 - Q_2 \qquad \eta = \frac{W}{Q_1}$

CARNOT CYCLE ENGINE

$\eta = 1 - \frac{Q_2}{Q_1} \qquad \eta_{carnot} = 1 - \frac{T_2}{T_1} \qquad \eta_{Carnot} = \frac{(h_1 - h_2) - (h_4 - h_3)}{h_1 - h_4}$

$r_w = \frac{(h_1 - h_2) - (h_4 - h_3)}{(h_1 - h_2)} \qquad s.s.c. = \frac{3600}{(h_1 - h_2) - (h_4 - h_3)}\ \text{kg/kwh}$

CHEMICAL EQUILLIBRIUM

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

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

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