UNIVERSITI
TEKNOLOGI
PETRONAS

FINAL EXAMINATION
JANUARY 2023 SEMESTER

COURSE : **PEB2023 - RESERVOIR ENGINEERING I**

DATE : **6 APRIL 2023 (THURSDAY)**

TIME : **2:30 PM - 5:30 PM (3 HOURS)**

INSTRUCTIONS TO CANDIDATES

1. Answer **ALL** questions in the Answer Booklet.
2. Begin **EACH** answer on a new page in the Answer Booklet.
3. Indicate clearly answers that are cancelled, if any.
4. Where applicable, show clearly steps taken in arriving at the solutions and indicate **ALL** assumptions, if any.
5. **DO NOT** open this Question Booklet until instructed.

Note :

i. There are **SEVEN (7)** pages in this Question Booklet including the cover page and Appendix.

ii. **DOUBLE-SIDED** Question Booklet.

1. a. The oil reservoir was discovered in Field X with the areas enclosed by the respective isopach lines and additional parameters are shown in **TABLE Q1a(i)** and **TABLE Q1a(ii)**.

TABLE Q1a(i) : Area of isopach lines.

Productive Area	Area (acres)
A_0	455
A_1	380
A_2	240
A_3	140
A_4	130
A_5	60
A_6	0

TABLE Q1a(ii) : Additional parameters

Properties	Values
Height, h (ft)	10
Initial oil formation volume factor, B_{oi} (bbl/STB)	1.42
Porosity, ϕ (%)	20
Initial water saturation, S_{wi} (%)	23
Recovery factor (%)	30

i. Calculate the volume of oil initially in place (OOIP) in STB using the combined method of Trapezoidal rule and Pyramidal formula (where appropriate).

[8 marks]

ii. Determine the reserves of the oil reservoir.

[2 marks]

b. Differentiate the developed and undeveloped reserves.

[4 marks]

c. With the aid of a diagram, explain the concept of overburden pressure and hydrostatic pressure in the fluid pressure regimes.

[6 marks]

d. A well test is conducted for an exploration well in Starhill field. It is revealed that the pressure in a reservoir at the oil-water contact (OWC) is 3630 psi. Calculate the pressure at the top of the reservoir if there is 650 ft of a continuous oil column.

[6 marks]

2. a. Generate and evaluate the drainage relative permeability plot for an oil-water system using Pirson's method. Given connate water saturation is 25%.

[10 marks]

b. Explain the hysteresis effect on the contact angle (wettability) for the water-wet reservoir.

[4 marks]

c. An oil well in Queen field is producing at a stabilized rate of 1200 STB/day. The well drains an area of approximately 42 acres. The reservoir properties and producing well data are given in **TABLE Q2.** Calculate the bottom hole flowing pressure for the well.
NOTE: 1 acre = 43560 ft^2.

[4 marks]

TABLE Q2 : Reservoir properties and producing well data.

Properties	Values
Permeability, k (mD)	120
Height, h (ft)	30
External pressure, p_e (psi)	2500
Wellbore radius, r_w (ft)	0.25
Oil viscosity, μ_o (cp)	2.0
Oil formation volume factor, B_o (bbl/STB)	1.4

d. Based on the primary reservoir characteristics, differentiate **THREE (3)** types of fluids to describe the fluid flow in porous media.

[6 marks]

3. a. **FIGURE Q3** shows the production characteristics for Reservoir A.

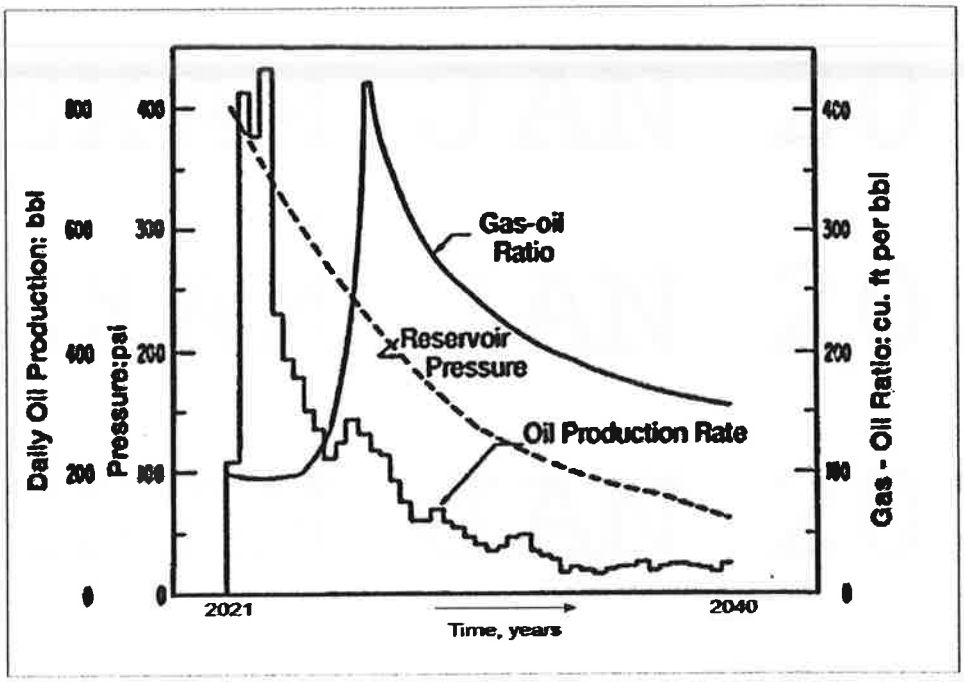

FIGURE Q3 : Production characteristics of Reservoir A.

i. Assess a suitable drive mechanism for Reservoir A and evaluate its production characteristics.

[10 marks]

ii. Propose a future development plan for Reservoir A and justify your answer.

[6 marks]

b. Describe **THREE (3)** reservoir characteristics in determining the best candidate reservoir for water flooding.

[6 marks]

c. Discuss the common problems associated with the gas injection as secondary recovery scheme and suggest a possible solution to encounter those problems.

[4 marks]

4. a. Describe the Van der Waals equation of state compared to the ideal gas equation.

[12 marks]

b. Discuss the Van der Waals two-parameter cubic equation of state.

[6 marks]

c. Describe the Soave-Redlich-Kwong (SRK) equation of state compared to the Redlich-Kwong equation of state.

[6 marks]

- END OF PAPER -

APPENDIX

$$\Delta V_B = \frac{h}{2}[A_n + A_{n+1}]$$

$$\Delta V_B = \frac{h}{3}\left[A_n + A_{n+1} + \sqrt{(A_n . A_{n+1})}\right]$$

$$N = \frac{7758\, V_B\, .\emptyset\, .\, S_{oi}}{B_{oi}}$$

$$N = \frac{V_{Bo}\, .\emptyset\, .\, (1 - S_{wi})}{5.615\, B_o}$$

$$S_w^* = \frac{S_w - S_{wc}}{1 - S_{wc}}$$

$$K_{rw} = \sqrt{S_w^*}\, S_w^3 \qquad K_{ro} = (1 - S_w^*)\left[1 - (S_w^*)^{0.25}\sqrt{S_w}\right]^{0.5}$$

$$\pi r^2 = 43560\, A$$

$$P = P_{wf} + \left[\frac{\mu_o B_o Q_o}{0.00708\, k\, h}\right] \times ln\left(\frac{r}{r_w}\right) \qquad P = P_{wf} + \left[\frac{\mu_o B_o Q_o}{0.00708\, k\, h}\right] \times ln\left(\frac{r}{r_w} - \frac{1}{2}\right)$$