230117 ①

To describe a reservoir fluid composition is needed, composition of components.

Amount of component: (methane, ethane etc.)

1. Mole fractions

$$z_i = \frac{n_i}{\sum n_j} = \frac{\text{number of moles comp. } i}{\text{total number of moles}}$$

$$\Rightarrow \quad \sum z_i = 1$$

2. Weight fractions:

$$w_i = \frac{W_i}{\sum W_j} = \frac{\text{weight comp } i}{\text{total weight}}$$

$$\sum w_i = 1$$

Define: mole

$$\text{mol} = \frac{\text{mass/weight}}{\text{Molar weight}}$$

- gmole : "gram mole" : 1 g of a substance contains $6.022 \cdot 10^{23}$ units

$$\text{gmol} = \frac{m(g)}{M_w}$$

- kg mole : "kg mole" : 1 kg of a substance contains $6.022 \cdot 10^{26}$ units.

$$\text{kg mol} = \frac{m\,(kg)}{M_w}$$

- lb mol : "pound mol" : 1 lb contains $424 \cdot 6.022 \cdot 10^{23}$ units

$$\text{lbmol} = \frac{m\,(\text{lb})}{M_w}$$

Typical component analysis

Nitrogen	N_2	inorganic gases	z_{N_2}
Carbon dioxide	CO_2		z_{CO_2}
Hydrogen sulfide	H_2S		z_{H_2S}
Methane	C_1		z_{C_1}
Ethane	C_2		z_{C_2}
Propane	C_3		z_{C_3}
Butane	C_4		z_{C_4}
Pentane	C_5		z_{C_5}
Hexane	C_6		z_{C_6}
Heptane	C_7	C_{7+}	z_{C_7}
Octane	C_8		z_{C_8}
Nonane	C_9		z_{C_9}
Decane	C_{10}	C_{10+}	z_{10+}

$$\sum z_i = 1$$

1 mol of a substance has a mass equal to the molar weight of $6.022 \cdot 10^{23}$ atoms

Atomic weight : $^{12}C = 12$ 1 mol ^{12}C = 12 g

atomic weight unit : u

Ex S : atom mass 32.07 u

1 g mol 32.07 g

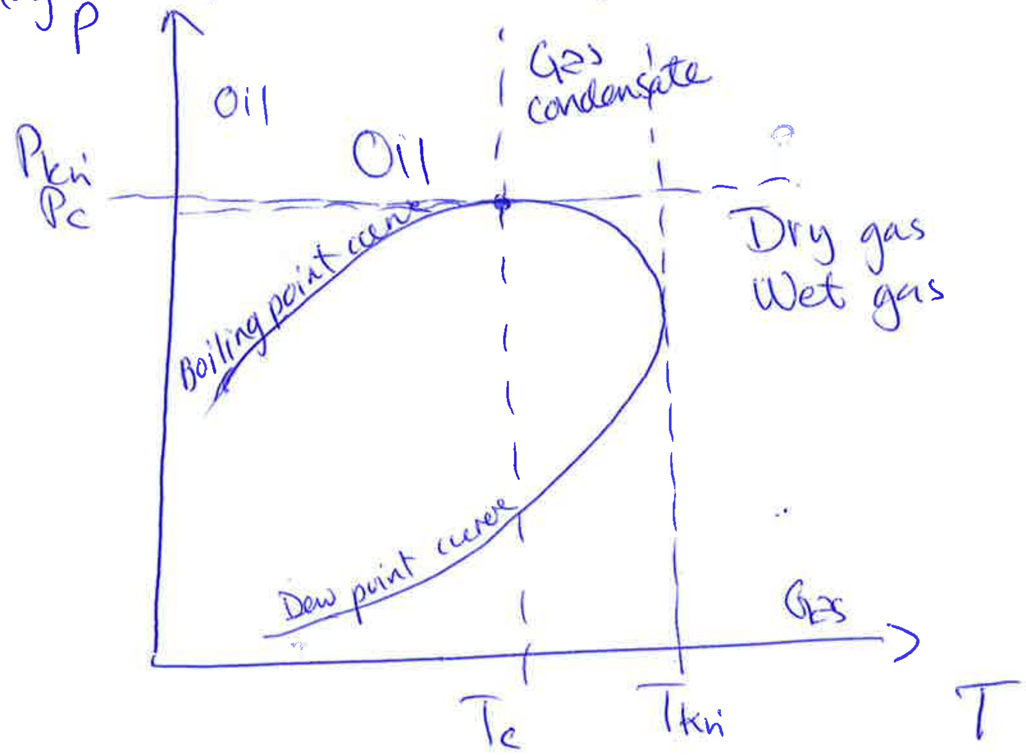
Mw = 32.07 g/gmol

RESERVOIR FLUID SYSTEMS

PT - DIAGRAMS

Characterization of fluid type can be done by looking at fluid behaviour at reservoir (res) and standard conditions (sc).

PT diagram of reservoir fluids



Most reservoir fluids can be defined by the placement of initial conditions, P_{res} T_{res}, relative to the two-phase envelope.

Dry gas: $T_{res} > T_{kri}$, sc (15°C, 1 Atm) outside the two-phase envelope. By pressure depletion only one phase gas

Wet gas: $T_{res} > T_{kri}$, sc inside the two-phase envelope

Gas-oil ratio

$$\frac{\text{Produced gas volume}}{\text{Produced oil volume}}$$

GOR > 30 000 SCF/SBL $(°API)_{STO} > 45$

stock tank oil

Gas condensate: $T_c < T_{res} < T_{kri}$ sc inside the phase envelope

3000 < GOR < 30000 SCF/SBL $(°API)_{STO}$ 45-55

Volatile oil: $T_{res} < T_c$, sc inside two-phase envelope

600 < GOR < 3000 SCF/SBL $(°API)_{STO}$ 35-55

Black oil: $T_{res} < T_c$, sc inside two-phase

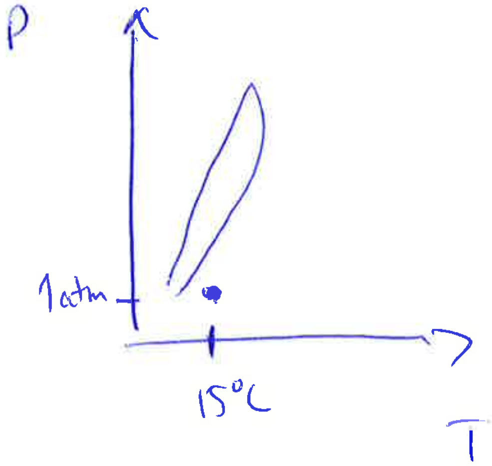
200 < GOR < 600 SCF/SBL

$$°API = \frac{141,5}{\gamma_o} - 131,5$$

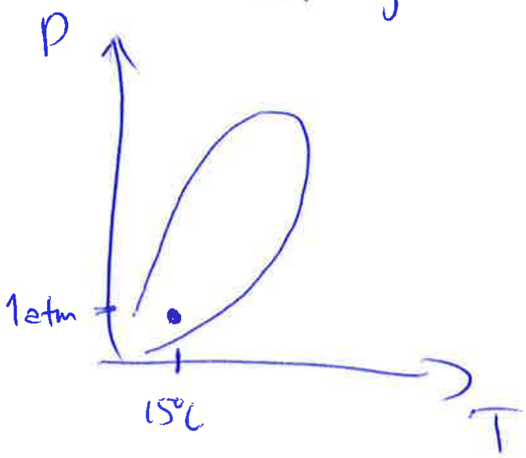
$(°API)_{STO}$ ≈ 15 - 35

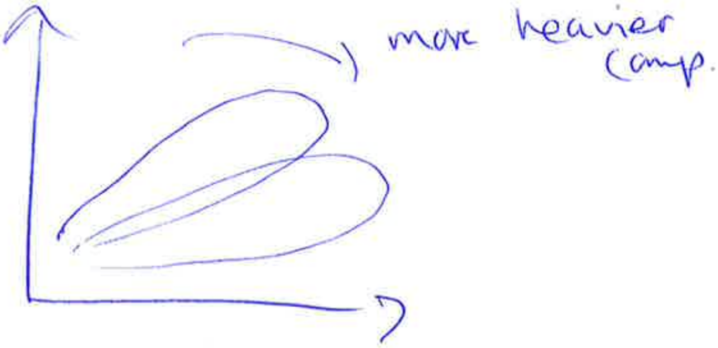
$$\gamma_o = \frac{\rho_o}{\rho_w}$$

Dry gas



Wet gas





Typical phase diagrams for reservoir fluids

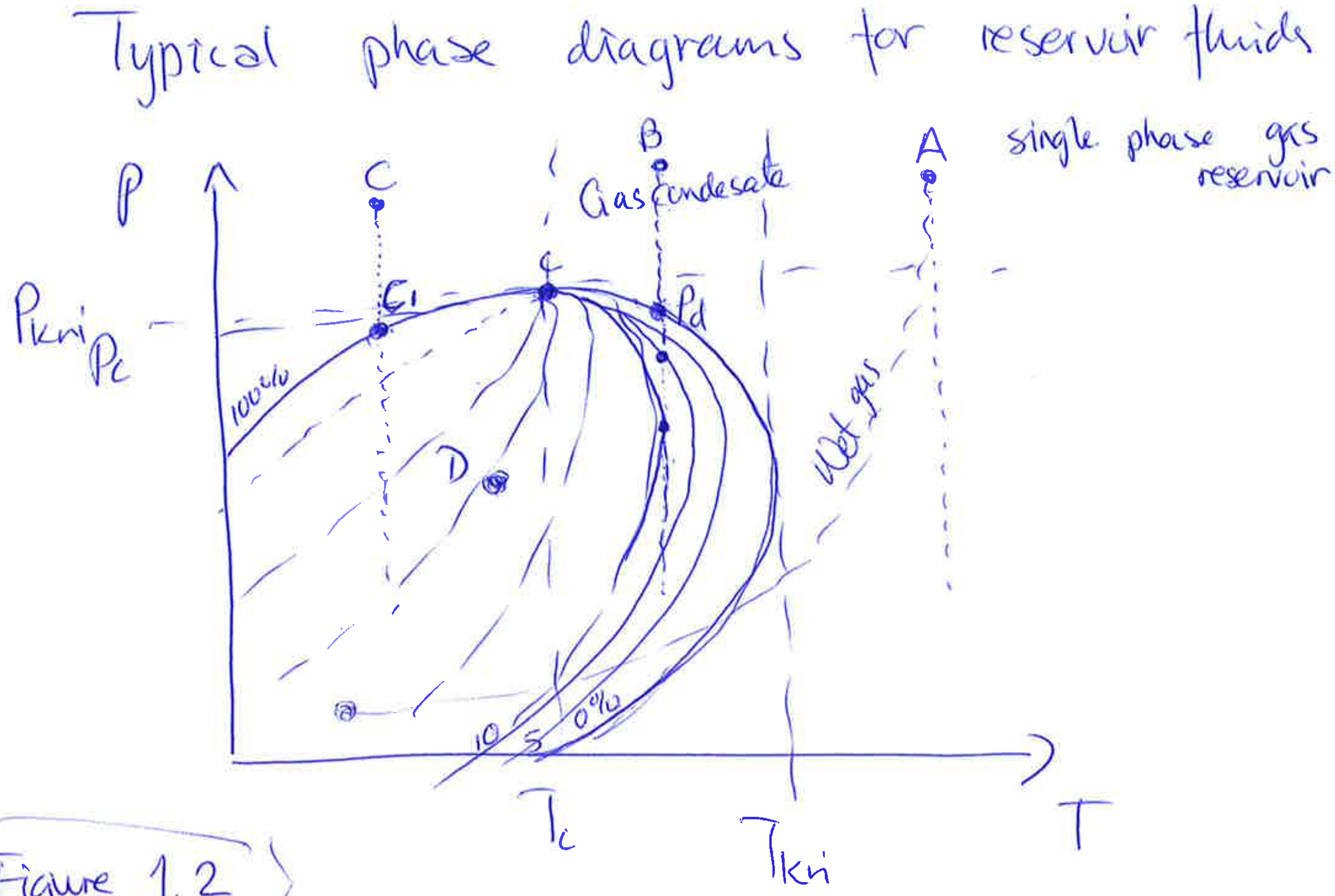


Figure 1.2

C: $T_{res} < T_c$
Pressure depletion to C_1: produce first bubble of gas, P_b, bubble point pressure.
Further pressure depletion into two-phase envelope, more gas is forming, lower oil.
Keep pressure above P_b in the reservoir
→ favourable

A: Pressure depletion in reservoir, $T_{res} \approx$ constant
single phase gas remains in reservoir.

When reservoir fluid is produced
Dry gas: sc is outside two phase envelope
produce only gas (GOR not applicable)

Wet gas: sc is inside two phase envelope.
produce gas and oil.

B Gas condensate. Reservoir fluid is one phase gas initially. But by pressure depletion to Pd - dew point pressure - first droplet of oil.

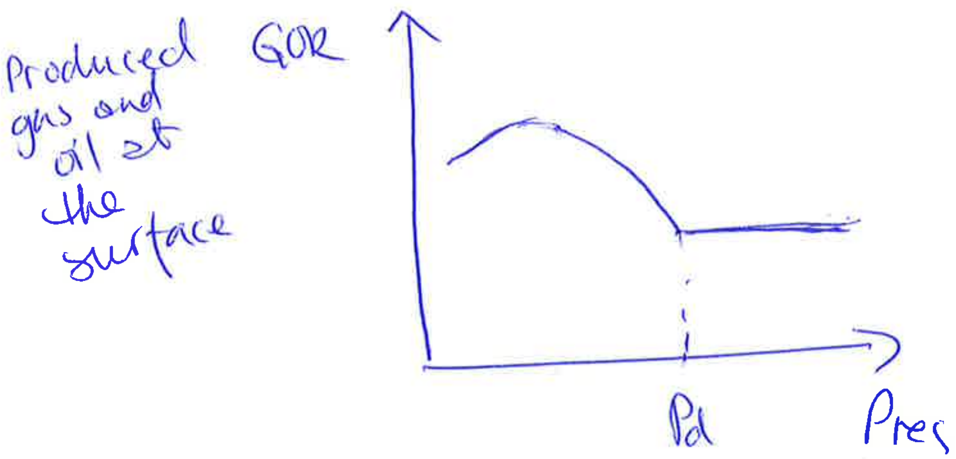
Retrograde condensation

~~Bssu~~ Retrograde gas condensates condensed

Further pressure depletion increases liquid volumes to a maximum, then evaporation will take place and amount of oil decreases. Condensed fluid remains in the reservoir, which changes the composition of the reservoir fluid. Not a constant composition of reservoir fluid.

Amount of oil and gas produced not constant. GOR changes.

GOR vs Pres



D: Reservoir initially in two-phase area
gascap above the oil zone.
Gas and oil have got their own
P-T diagrams.

$P_{res} = P_b(oil) = P_d(gass)$