

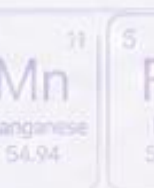
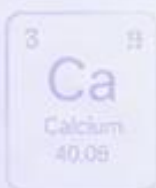
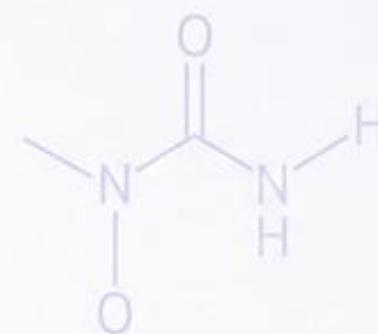
Unit 6

Equilibrium



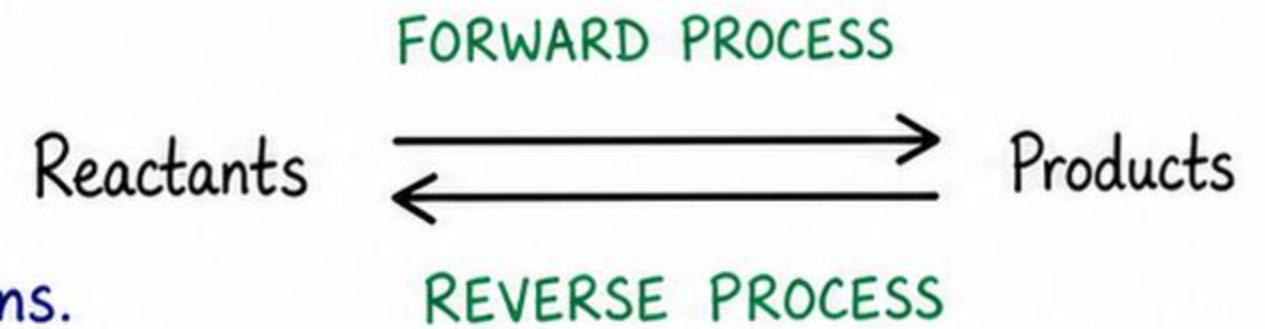
Chemistry Notes | Class 11

$$K_c = \frac{[C]^c [D]^d}{[A]^a [B]^b}$$



EQUILIBRIUM - DYNAMIC BALANCE

- Definition: Equilibrium is the state in which two opposing processes occur at equal rates.
- It is dynamic, not static: particles keep changing in both directions.
- At equilibrium, rate of forward reaction = rate of reverse reaction.
- Concentrations and other macroscopic properties remain constant with time.
- A closed system and fixed temperature are needed.
- Equilibrium mixture: the mixture of reactants and products present at equilibrium.

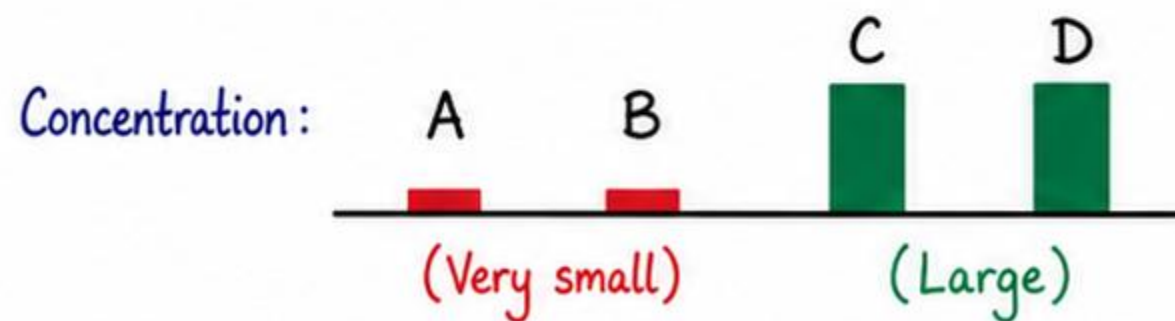


At equilibrium,
rate (forward)
= rate (reverse)

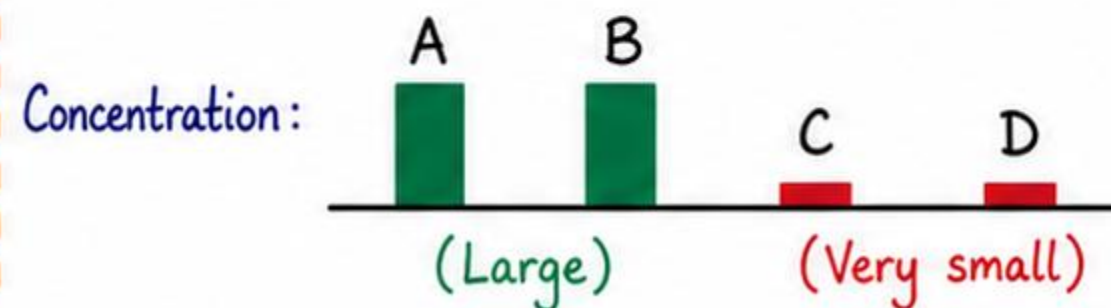
$$r_f = r_r$$

EXTENT OF A REVERSIBLE REACTION

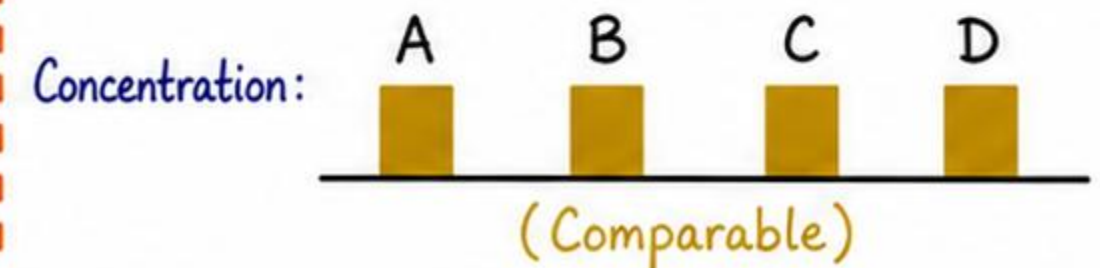
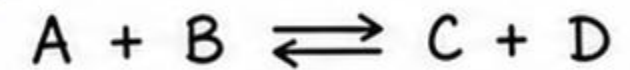
- ① Products strongly favoured - very little reactant remains.



- ② Reactants strongly favoured - only a little product forms.



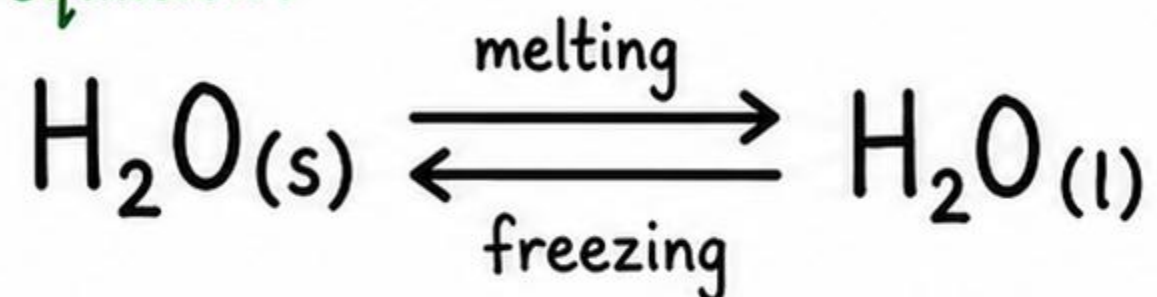
- ③ Both sides appreciable - reactants and products are comparable.



★ Final takeaway: Equal rates do NOT mean equal concentrations.

SOLID-LIQUID EQUILIBRIUM

1. Central reversible equation:



2. Definition:

At solid-liquid equilibrium, melting and freezing occur at equal rates.

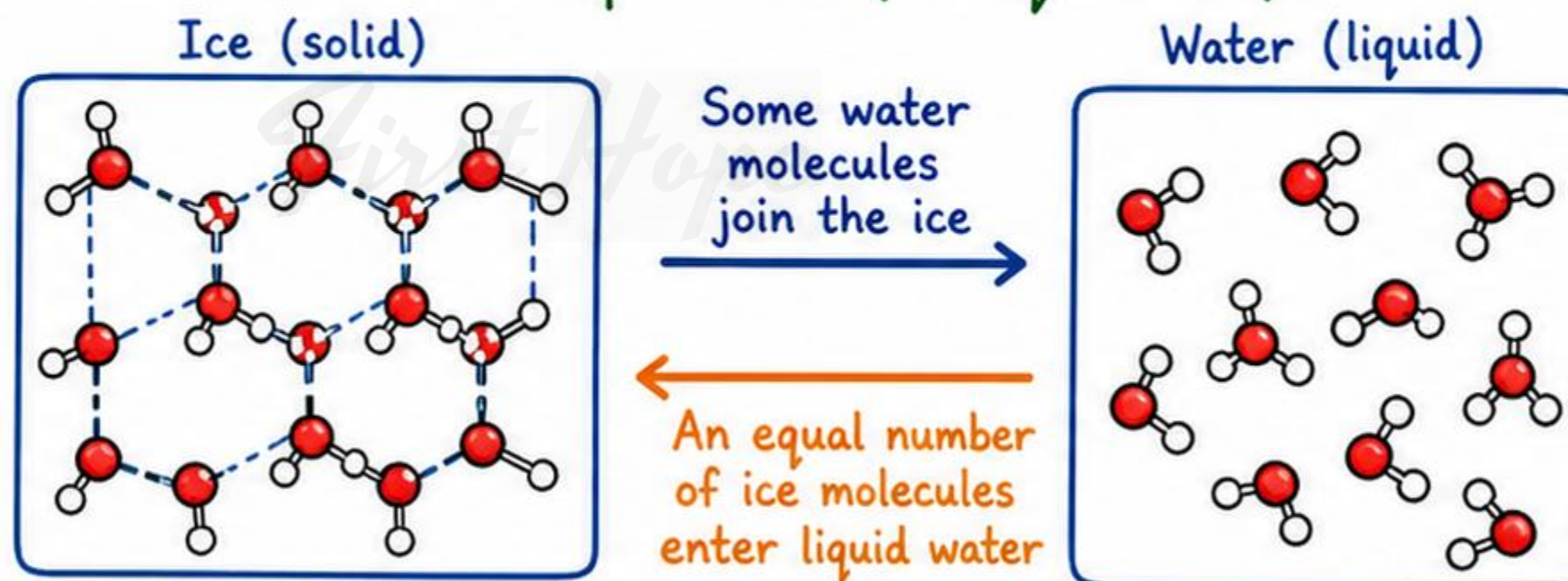
3. Conditions for ice-water equilibrium:

- 273 K and 1.013 bar (1 atm)
- closed, perfectly insulated system

5. Rate condition at equilibrium:

rate of melting = rate of freezing

4. Particle-level explanation (at equilibrium):



★ Dynamic, not static

★ Both phases coexist only at the required temperature and pressure.

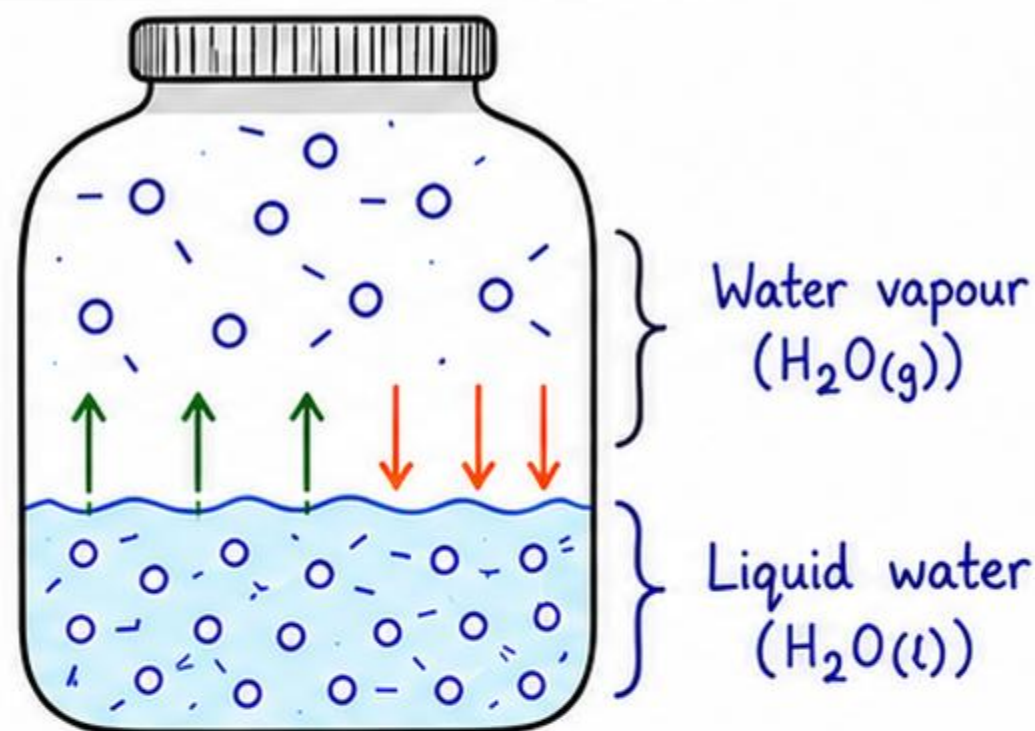
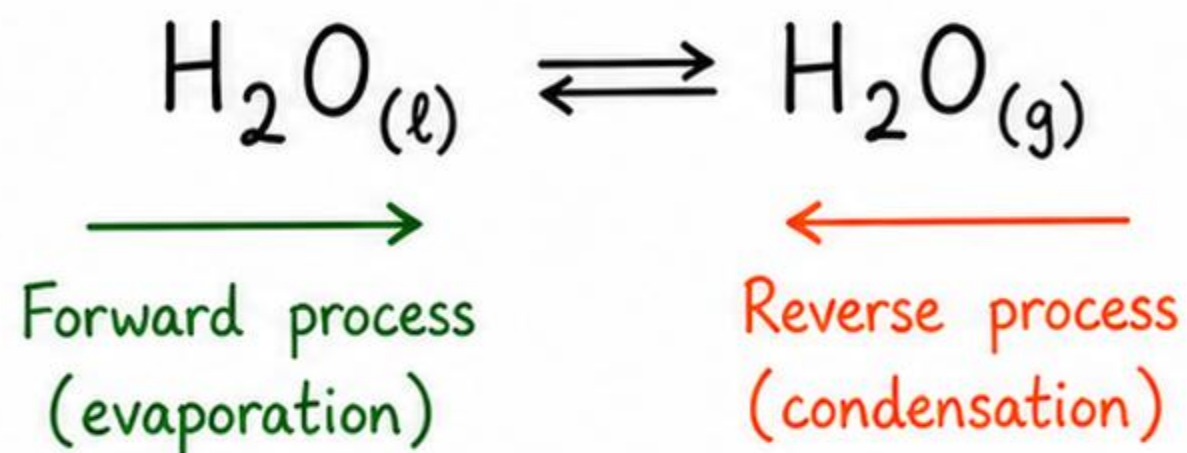
6. What remains constant:

At solid-liquid equilibrium, mass of ice and mass of water remain constant with time, but molecular exchange continues.

7. Definition (exact):

Normal melting point / normal freezing point: the temperature at which solid and liquid phases of a pure substance are in equilibrium at 1.013 bar.

LIQUID-VAPOUR EQUILIBRIUM



A closed system is necessary.

Step sequence:

1. At first, evaporation is faster because very little vapour is present.
2. Vapour molecules increase, so condensation becomes faster.
3. Equilibrium is reached when both rates become equal.



rate of evaporation = rate of condensation

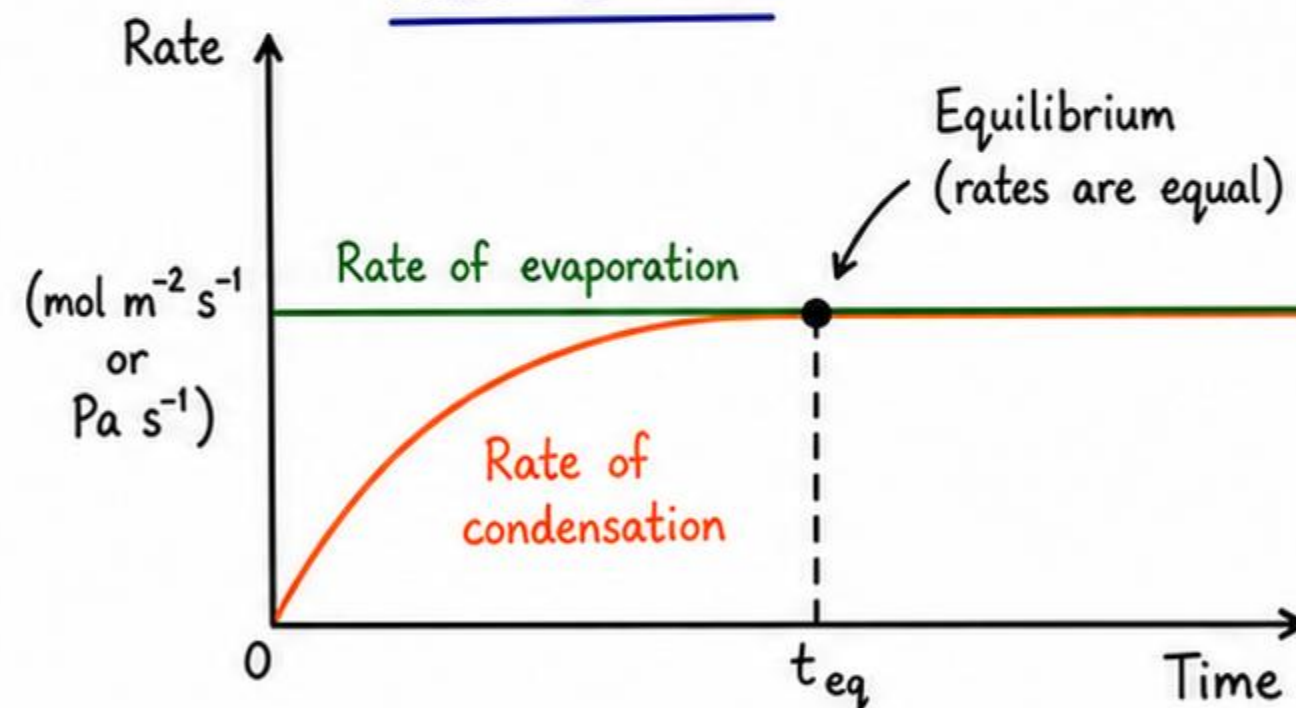
Definition: Equilibrium vapour pressure: the constant pressure exerted by vapour above its liquid at a given temperature.

Explanation: At equilibrium, the liquid amount and the vapour amount remain constant. However, molecules keep crossing the surface:

- ↑ Molecules leave the liquid (evaporation).
- ↓ Molecules return to the liquid (condensation).

Rate is about how fast the process occurs.
Amount is how much is present.

Rate vs Time

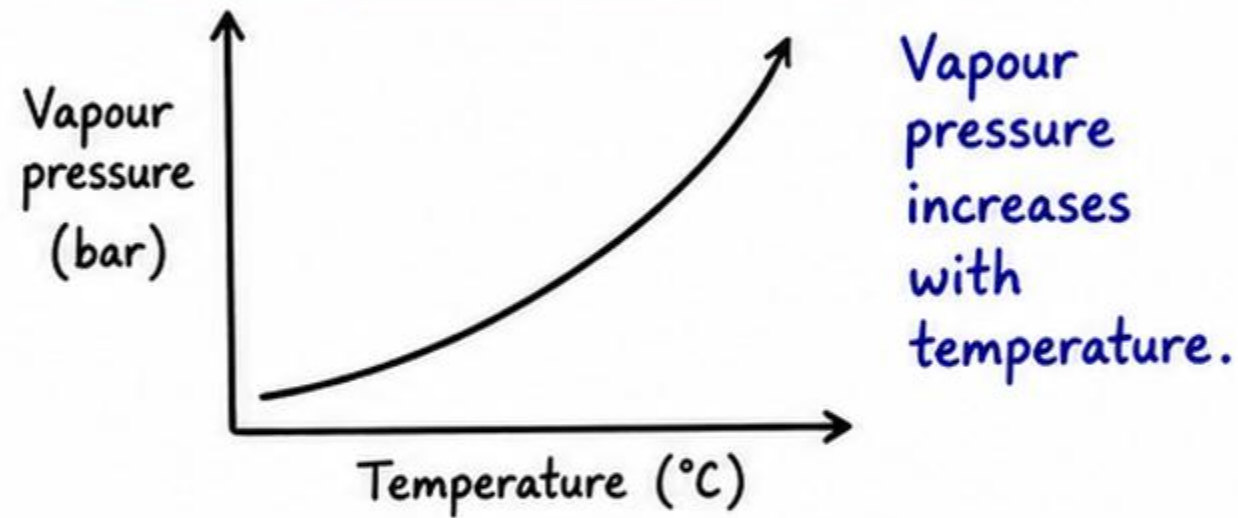


- Evaporation rate is nearly constant.
- Condensation rate increases with time.
- At equilibrium (t_{eq}), both rates are equal and remain equal thereafter.

VAPOUR PRESSURE, VOLATILITY AND BOILING

- ★ 1. Vapour pressure:
pressure exerted by vapour in equilibrium with its liquid at a given temperature.

2. Vapour pressure vs Temperature

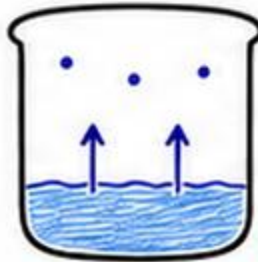


3. Volatility and boiling point

- Higher vapour pressure → more volatile → lower boiling point.
- Lower vapour pressure → less volatile → higher boiling point.



More volatile
(higher vapour pressure)
Lower boiling point



Less volatile
(lower vapour pressure)
Higher boiling point

4. Normal boiling point

- ★ Normal boiling point: temperature at which a liquid and its vapour are in equilibrium at 1.013 bar.
- ★ For water: 100 °C at 1.013 bar.

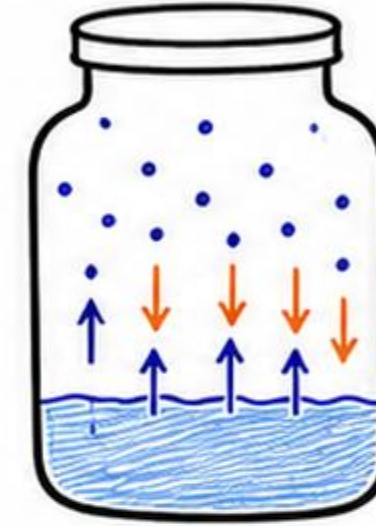
5. Effect of altitude



At high altitude, atmospheric pressure is lower, so water boils below 100 °C.

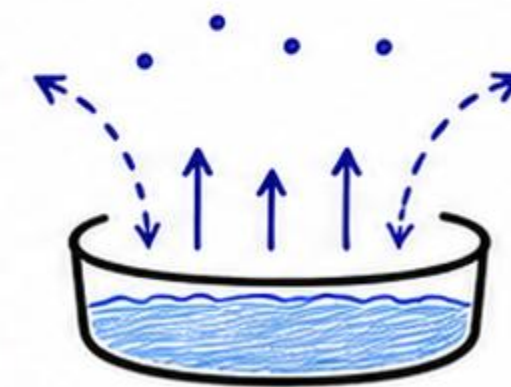
6. Open vs Closed system

★ Closed vessel



- Evaporation and condensation can become equal; equilibrium is possible.

★ Open vessel



- Vapour escapes, condensation is too small; equilibrium is not reached.



TAKEAWAY:

Boiling occurs when vapour pressure equals external pressure.

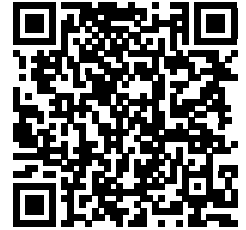


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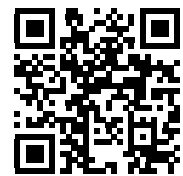


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