# I.5 Liquid State

Civil Services 2016–2026: **18** parts, **155** marks · IFoS 2016–2025: **0** parts, **0** marks

**Syllabus.** Kelvin equation; surface tension and surface energy, wetting and contact angle, interfacial tension and capillary action.

| Marks | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| CSE | 0 | 10 | 15 | 15 | 20 | 10 | 10 | 25 | 10 | 20 | 20 |
| IFoS | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |

**How to use this chapter.** Read every question once and mark the ones that repeat. Pick three, write them by hand against the clock (about 7 minutes for 10 marks), then compare with the model answers on vkcscience.com.

## 2026

### CSE 2026 · Q1(b) Liquid of higher surface tension: five properties [5 marks]

The surface tension of liquid *A* is greater than that of liquid *B*. Which liquid will show larger (i) vapour pressure, (ii) cohesive force, (iii) boiling point, (iv) capillary action and (v) wetting property? Explain.

### CSE 2026 · Q2(b) Interfacial tension between two immiscible liquids; Pressure difference across an ethanol droplet of radius 220 nm [15 marks]

(i) Two immiscible liquids *A* and *B* have surface tension values $\gamma_A$ and $\gamma_B$, respectively. When both the liquids are taken in a container, then what would be the interfacial tension between the two liquid phases? (Given : $\gamma_A > \gamma_B$)

(ii) Calculate the pressure differential across the surface of ethanol spherical droplet of radius 220 nm at 20 °C. The surface tension of ethanol at that temperature is 22.39 mN $m^{-1}$.

## 2025

### CSE 2025 · Q1(e) Superheating of liquids and the Kelvin equation [5 marks]

Why do liquids become superheated before boiling? Explain using Kelvin equation.

### CSE 2025 · Q3(b) Droplets made from one mole of water [15 marks]

Suppose that 10.0 J of work is required to create droplets of uniform size from a mole of water in bulk at 25 °C and 1 atm pressure.

(i) Assuming that surface tension is independent of area, calculate the radius of the droplets.

(ii) Calculate the number of water molecules in a droplet.

Given: Surface tension of water = 0.072 $J/m^2$

## 2024

### CSE 2024 · Q3(b) Surface tension: ethanol or dimethyl ether; Pressure difference across a water droplet of radius 150 nm [10 marks]

(i) Which of the following liquids has greater surface tension: Ethanol or Dimethyl ether
Explain the answer with reasons. *5*

(ii) Calculate the difference in pressure across the liquid-air interface for a water droplet of radius 150 nm. *5*

## 2023

**CSE 2023 · Q1(e)(ii) Surface tension, contact angle and loss of gravity** [5 marks]

(ii) The surface tension of liquid *A* is seven times higher than that of liquid *B*.
(1) Which liquid is expected to have higher contact angle with glass?
(2) 10 mL of each of these liquids are placed in separate 100 mL glass beakers. How do these liquids respond if the gravitational field is switched off?

**CSE 2023 · Q4(b) Pressure difference needed to drink through a tilted straw** [10 marks]

A 15 cm drinking straw is inserted in a glass of water at an angle 45°. What pressure difference (in torr) must be generated across the length of the straw to drink water? The density of water is 1.0 g $cm^{-3}$.

**CSE 2023 · Q4(c) Diameter of a capillary from the pressure needed to blow a bubble** [10 marks]

A capillary tube of radius *r* is inserted into a liquid to blow a bubble of the same radius *r*. If the excess pressure required to blow the bubble is 2.16 torr, then what is the diameter of the capillary tube in cm? The surface tension of the liquid is 0.072 N $m^{-1}$.

## 2022

**CSE 2022 · Q4(c) Capillary rise of two liquids in the same tube** [10 marks]

Consider two liquids *A* and *B* such that *A* has half of the surface tension and twice the density of *B*. If liquid *A* rises to a height of 2.0 cm in a capillary, what will be the height to which liquid *B* will rise in the same capillary.

## 2021

**CSE 2021 · Q3(a) Surface energy when one drop is split into 125 drops** [10 marks]

A drop of water, 0.4 cm in radius, is split up into 125 tiny drops. Find the increase in surface energy. [$\gamma_{water}$ (surface tension of water) = 72 dynes/cm]

## 2020

**CSE 2020 · Q4(b) Capillary action, contact angle and γ=½hρ gr** [10 marks]

Explain the phenomenon of capillary action with showing relation between the angle of contact and the nature of liquid and derive the expression, $\gamma = \frac{1}{2}h\rho gr$ (Symbols have usual meanings).

**CSE 2020 · Q6(c) Excess pressure inside a soap bubble** [10 marks]

A spherical soap bubble of volume $\frac{\pi}{6}$ $cm^3$ stands suspended in air. If the interfacial tension for soap solution-air interface is 27 dyn $cm^{-1}$, calculate the excess pressure inside the bubble.

## 2019

**CSE 2019 · Q4(b) Vapour pressure of a curved water surface, radius 10 nm (Kelvin)** [15 marks]

Calculate the vapour pressure of a water bubble of radius $10^{-8}$ m at 20 °C. Vapour pressure of pure water at 20 °C is 23.76 Torr. Surface tension of water is $72.76 \times 10^{-3}$ N $m^{-1}$; density of water is 0.9982 g $cc^{-1}$.

## 2018

**CSE 2018 · Q2(b)(i) Significance of the Kelvin equation** [5 marks]

Explain the significance of Kelvin equation.

**CSE 2018 · Q3(d) Capillary action of water and mercury in tubes of two radii** [10 marks]

Draw diagrams showing the capillary action of (i) water and (ii) mercury in two glass tubes of different radii. Explain their behavior also.

## 2017

**CSE 2017 · Q2(b) Two mercury drops merge: change of area and energy** [10 marks]

Find the change in surface area and energy when two identical mercury droplets of diameter 2 mm merged isothermally to one drop. Given that surface tension of mercury is 490 dyne $cm^{-1}$ at experimental temperature.