```html

# Fluid Mechanics

## Vapor Pressure and Cavitation

**a) What is Vapor Pressure? How is it related to Saturation Pressure?**

**Step-by-Step Answer:**

**1. Definition of Vapor Pressure**

Vapor pressure is the pressure exerted by a vapor in equilibrium with its liquid (or solid) phase at a given temperature in a closed system.

- **Explanation:** In a closed container, a liquid will evaporate until the particles in the vapor phase exert a pressure on the liquid. This pressure is called the vapor pressure.
- **Supporting Statement:** Vapor pressure is indicative of a liquid's evaporation rate and volatility.

**2. Relationship to Saturation Pressure**

Saturation pressure is the pressure at which a liquid is in equilibrium with its vapor at a given temperature; essentially, it is another term for vapor pressure at a specific temperature.

- **Explanation:** When a liquid's vapor pressure equals the surrounding pressure, the liquid boils. Thus, vapor pressure at equilibrium is the saturation pressure.
- **Supporting Statement:** The concepts are often interchangeable as both refer to the pressure at the boiling point of a liquid at a given temperature.

**b) What is Cavitation? What Causes It?**

**Step-by-Step Answer:**

**1. Definition of Cavitation**

Cavitation is the formation and collapse of vapor pockets (cavities) in a liquid due to local drops in pressure.

- **Explanation:** When the local pressure in a fluid drops below its vapor pressure, vapor pockets form. When these pockets collapse, they can cause damage to surfaces nearby.
- **Supporting Statement:** Cavitation is often problematic in hydraulic machinery and marine propellers, where it can lead to material erosion and mechanical failure.

**2. Causes of Cavitation**

Cavitation is primarily caused by a drop in pressure below the vapor pressure of the liquid, often due to rapid fluid motion or mechanical action (such as in pumps, turbines, or propellers).

- **Explanation:** High-velocity fluid flows or mechanical impacts can create localized low-pressure zones, leading to vapor formation and subsequent collapsing.
- **Supporting Statement:** This phenomenon is prevalent in components under high dynamic stresses where control of fluid pressure is critical.

**c) Analysis of a Propeller at 20°C**

**Given Data:**

- Operating temperature: 20°C
- Pressure at the tips of the propeller drops to: 1 kPa
- Vapor pressure of water at 20°C = 2.34 kPa

**Step-by-Step Answer:**

**1. Introduction and Given Data**

Operating temperature of the propeller: 20°C.
Minimum pressure encountered at the propeller tips: 1 kPa.
Vapor pressure of water at 20°C: 2.34 kPa.

- **Explanation:** The conditions provided set the framework for determining if cavitation will occur.
- **Supporting Statement:** The pressure at the propeller tips must be compared with the vapor pressure of water to assess cavitation risk.

**2. Compare Operating Pressure with Vapor Pressure**

\[ P_{\text{tip}} < P_{\text{vapor}} \] Operating pressure at propeller tips = 1 kPa
Vapor pressure of water at 20°C = 2.34 kPa

- **Explanation:** The pressure at the tips of the propeller (1 kPa) is less than the vapor pressure of water (2.34 kPa) at 20°C.
```

- **Supporting Statement:** Cavitation is likely to occur if local pressures fall below the liquid's vapor pressure.

3. Conclusion on Cavitation Risk

Since the pressure at the propeller tips (1 kPa) is below the vapor pressure (2.34 kPa), cavitation will occur.

- **Explanation:** The local pressure drop ensures vapor pockets will form, leading to cavitation.
- **Supporting Statement:** Every point at which the local pressure is below the vapor pressure, cavitation is imminent.

> **Final Solution:**
>
> 1. Vapor pressure is the equilibrium pressure of a vapor in a closed system, equal to saturation pressure.
> 2. Cavitation is the formation and collapse of vapor pockets caused by local pressure drops below vapor pressure.
> 3. With the propeller pressure dropping to 1 kPa, below water’s 2.34 kPa vapor pressure at 20°C, cavitation will occur.

```
```