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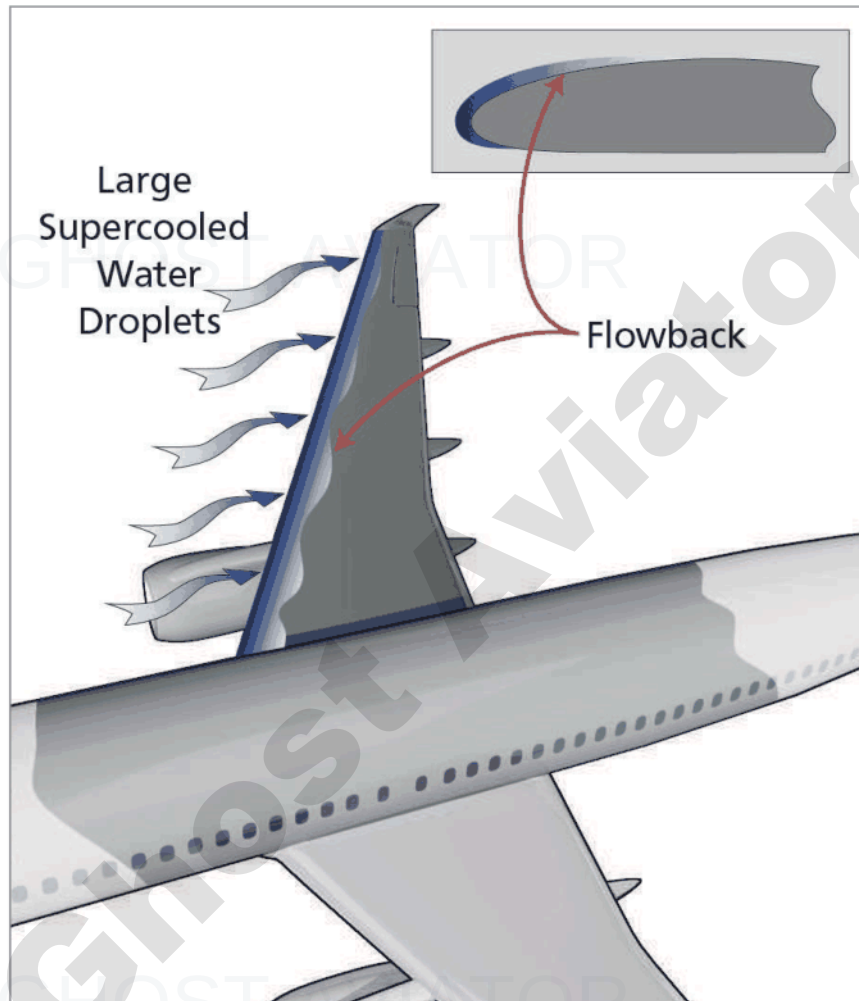
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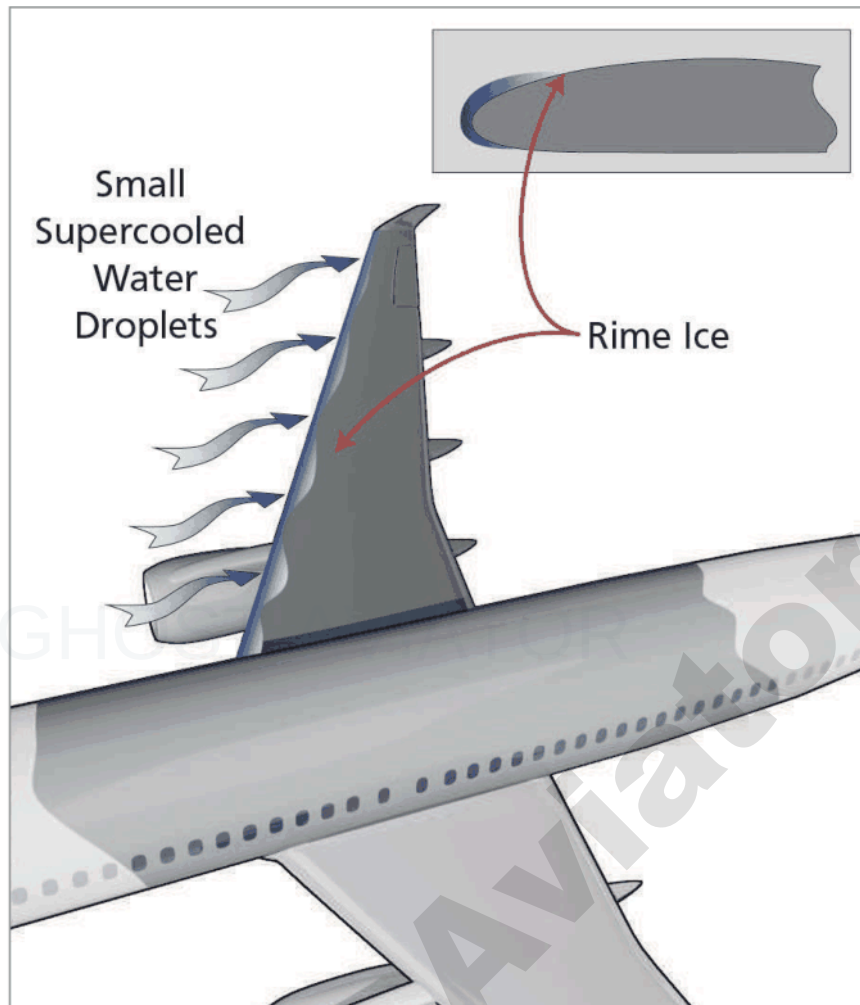
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1. Types of Airframe Ice

Definition — Ice Accretion: The accumulation of ice on airframe surfaces, engine intakes, and instruments due to contact with supercooled water droplets or water vapour in sub-freezing conditions.



Clear ice formation



Rime ice formation

Rime Ice

Rime ice forms by the **instantaneous freezing** of small supercooled water droplets on impact. Air is trapped between droplets → *opaque, milky-white, rough* appearance. It is **light and porous** and builds up on leading edges and into the airstream. Less structurally dangerous than glaze but disrupts airflow significantly.

Glaze Ice (Clear Ice / Translucent Rime)

Also called **clear ice** because of its glassy appearance. Forms from **large supercooled water droplets** that spread backwards after impact before freezing. Very little air is trapped → *clear, hard, dense, heavy*. Deposits on leading edges, struts, and propeller blades. Initial deposit may have flat surface; subsequent deposits build up in lumps.

⚠ **Most hazardous type of icing.** Glaze ice:

- Is **sticky** — cannot be easily shaken off; if it breaks it comes away in dangerous lumps.
- Alters aerodynamics and is **heavy** — poses serious aviation hazard.
- May set up **vibrations** due to unequal loading of wings, struts, and propeller blades.
- Comparable to ice cubes in a refrigerator — smooth, hard, transparent.

Hoar Frost

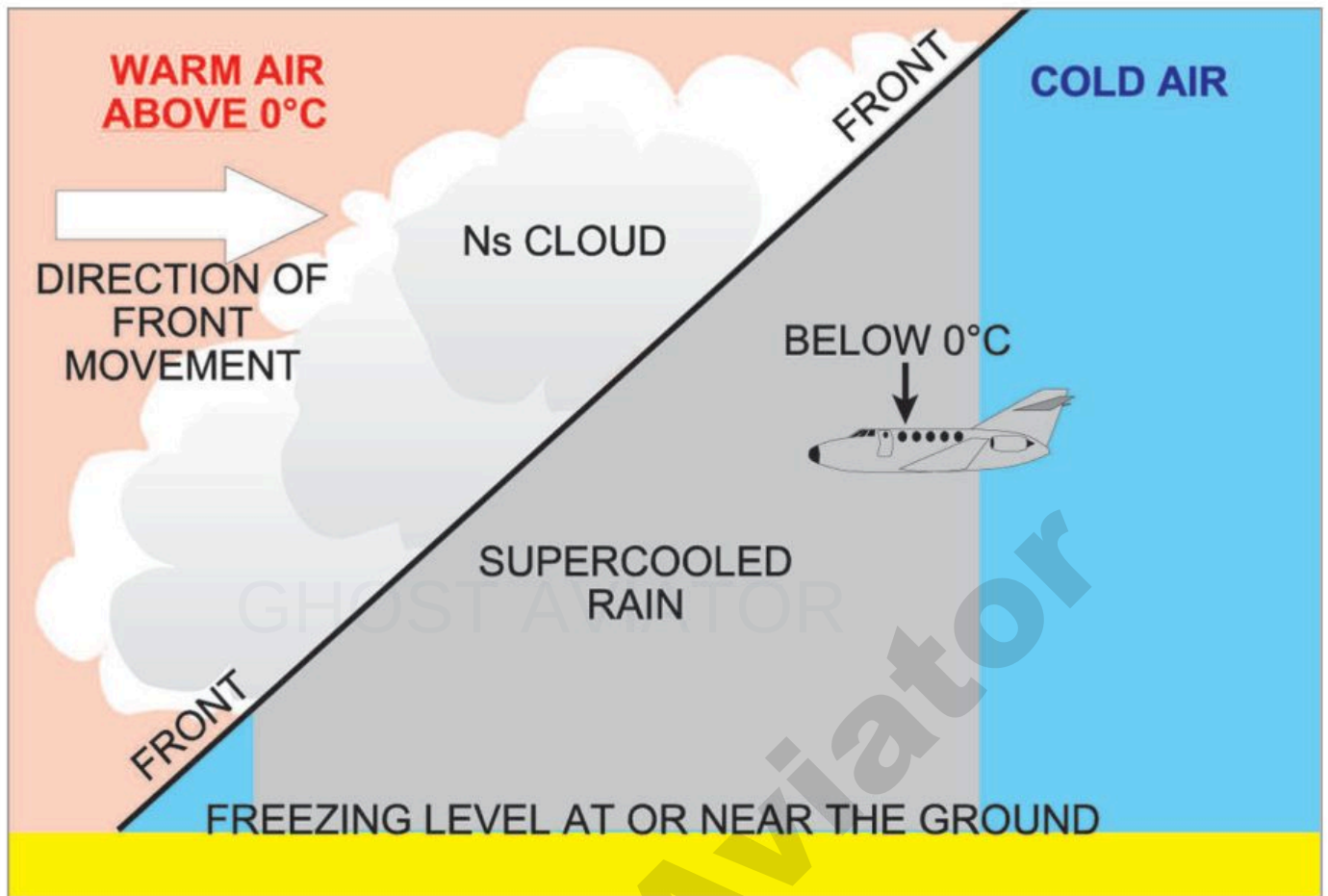
Occurs in **moist, cloudless air** when aircraft surface temperature falls below **0°C** due to **sublimation of water vapour** onto feathery ice crystals. Also forms when a cold-soaked aircraft descends into warmer moist air. It gives a white crystalline coating and is generally less hazardous in flight but can be dangerous on takeoff (disrupts laminar flow).

flowchart TD

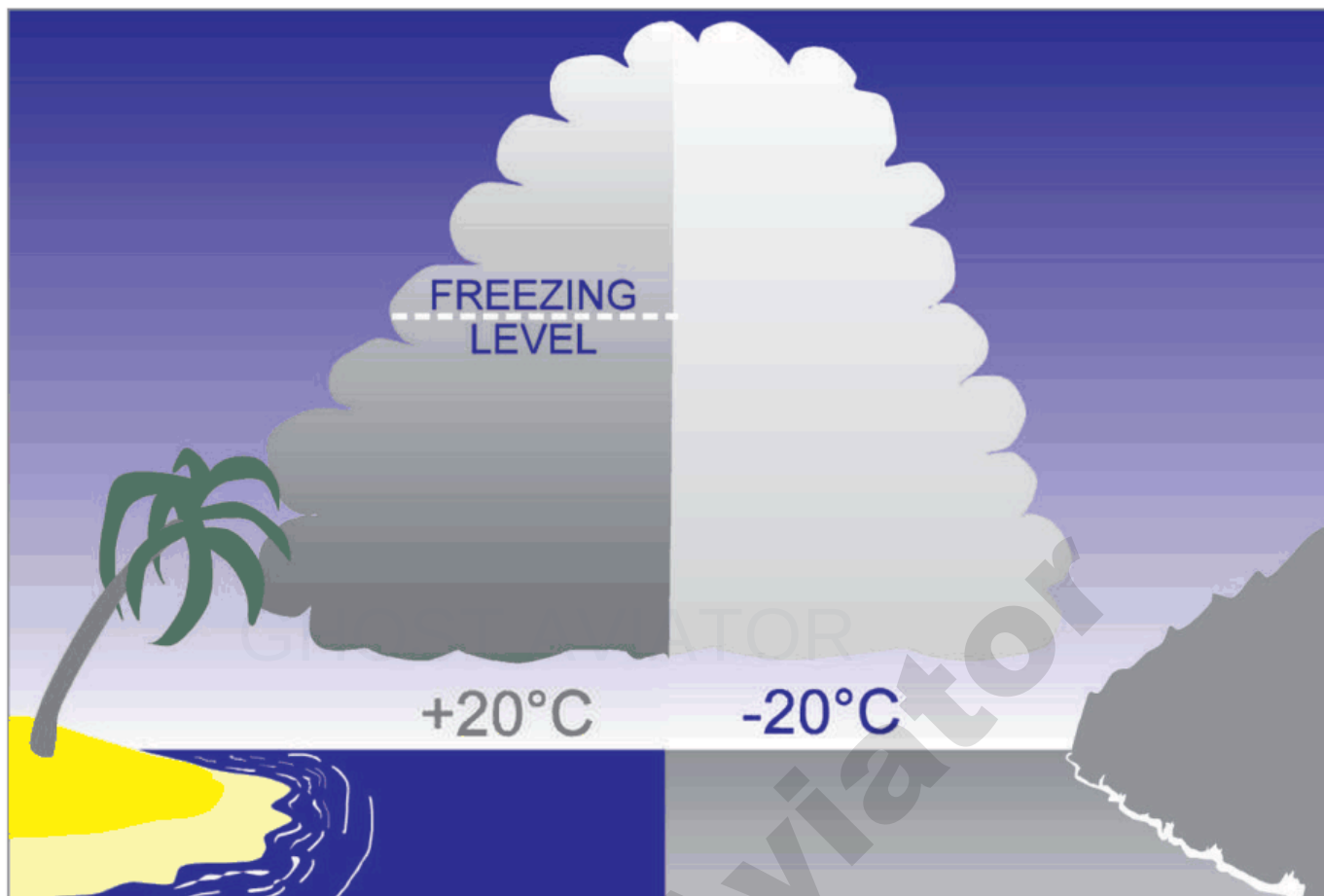
```
A[Supercooled Water Droplets in Cloud] -->|Small drops, instant freeze| B[RIME ICE\nOpaque, rough, light, porous]
A -->|Large drops, spread before freezing| C[GLAZE / CLEAR ICE\nTransparent, hard, heavy, dangerous]
D[Water Vapour below 0°C, no cloud] -->|Sublimation| E[HOAR FROST\nFeathery crystals on surface]
B -->|In mixed cloud 0° to -40°C| F[MIXED ICE\nCombination of Rime + Glaze]
```

2. Temperature Range for Airframe Icing

The optimum temperature range for cumulonimbus clouds in which different degrees of icing are likely are:



Freezing rain



Icing and the freezing level

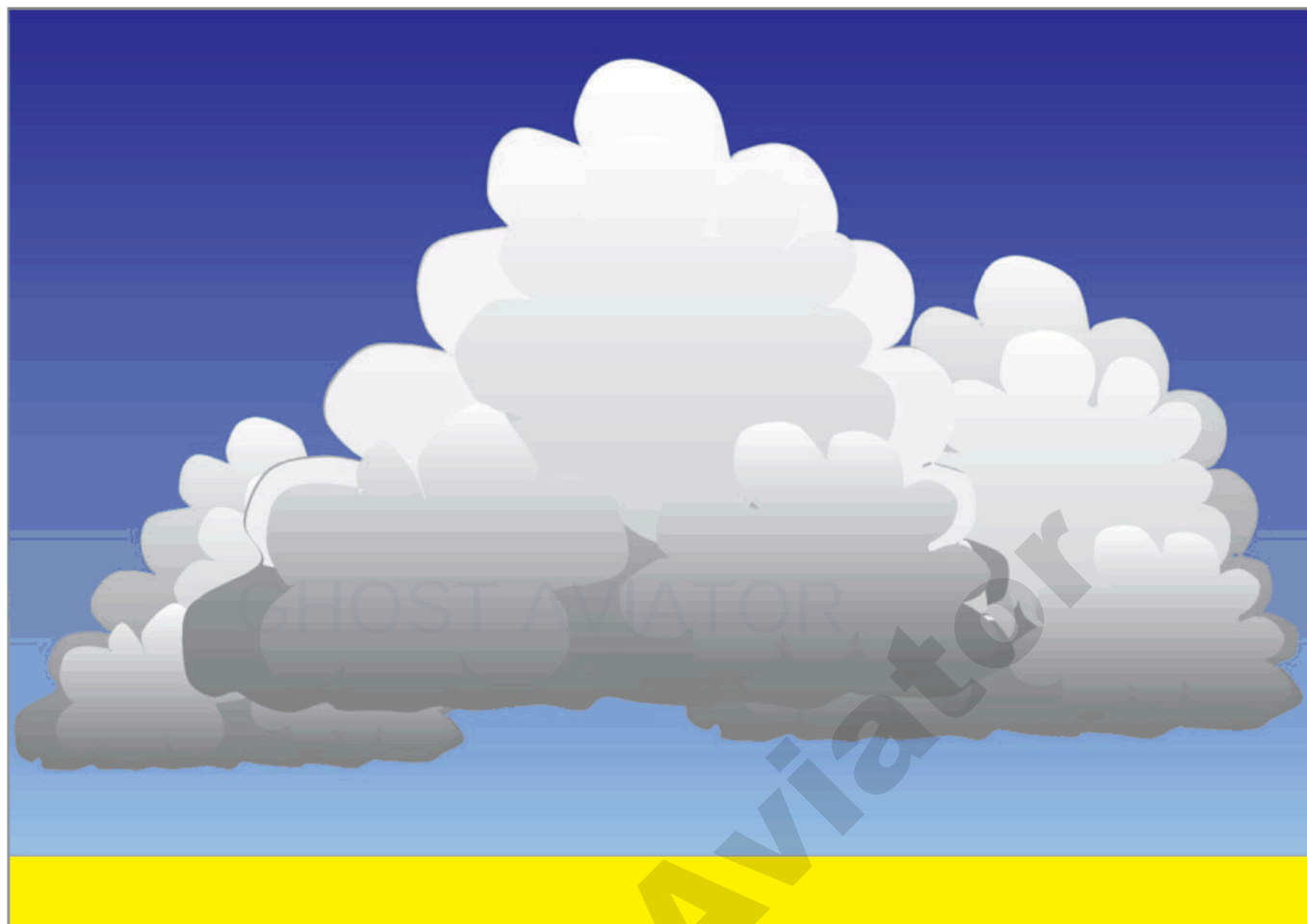
Severity	Temperature Range
Severe	0°C to -7°C
Moderate	-7°C to -12°C
Light	-12°C to -20°C
Very Light	-20°C to -40°C

🧠 **Mnemonic — "Severe Mild Lite Very":** 0 → -7 → -12 → -20 → -40. The warmer the temperature (closer to 0°C), the more liquid water content and thus more severe icing. Below -40°C, droplets are almost entirely ice crystals — icing is negligible.

3. Airframe Icing in Relation to Cloud Forms

Ice accretion is dependent primarily on the **size** and **number** of drops in a cloud.

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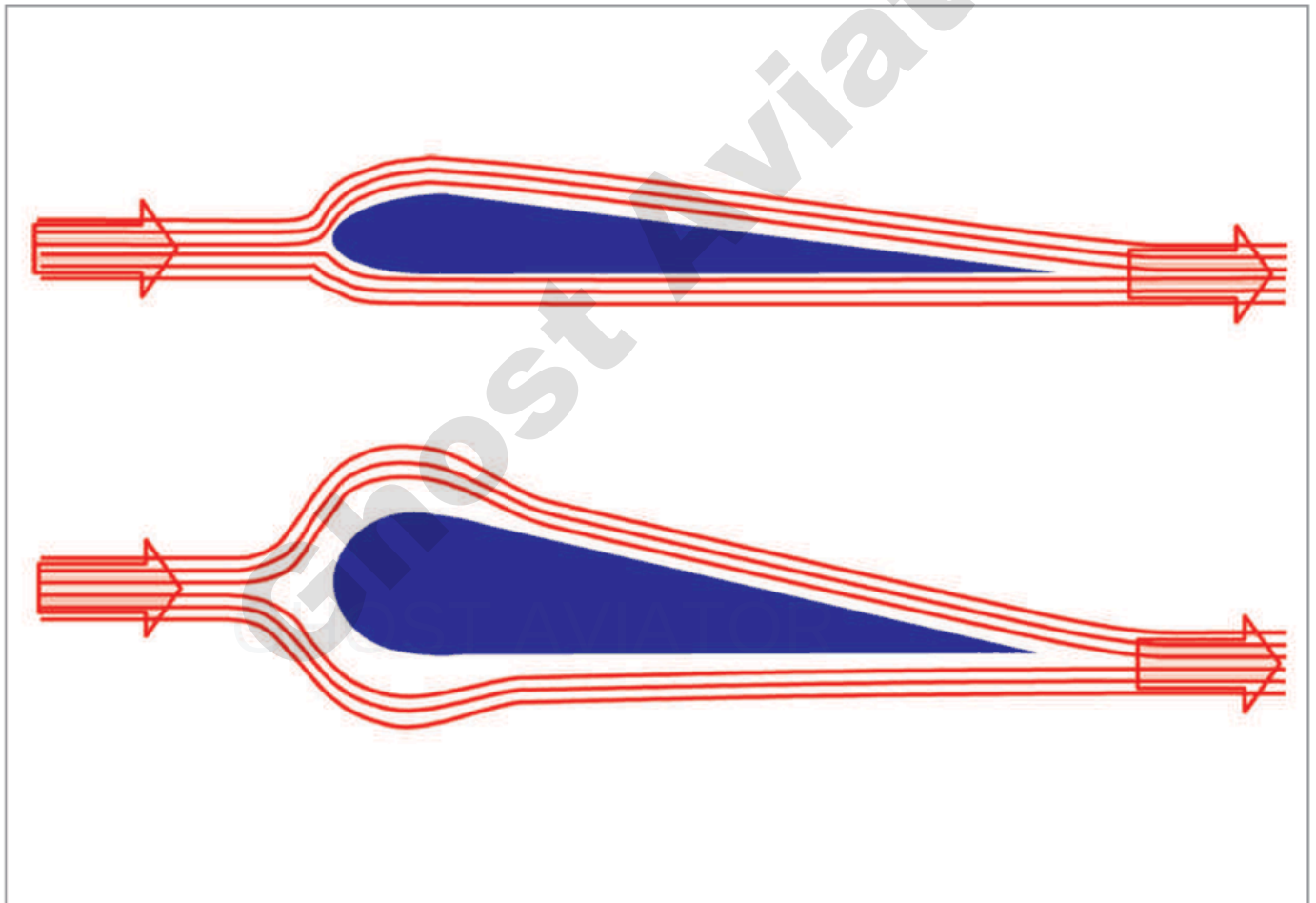
Cumulonimbus and icing

Cloud Type	Icing Risk	Remarks
Ci, Cs, Cc	Negligible	Consist mostly of ice crystals
As, Ns	Light to Moderate	Supercooled water drops + ice crystals in varying proportions
Ac	Light to Moderate	Severe icing possible in mountainous areas
TCu	Light to Severe	May range from light to severe type up to -20°C level
Cb	Light to Severe (up to -20°C)	Below -20°C level, temperature severe icing is not significant
St, Sc, Ac, Cu, Ns	Rime / Glazed	Occur at -10°C to -40°C

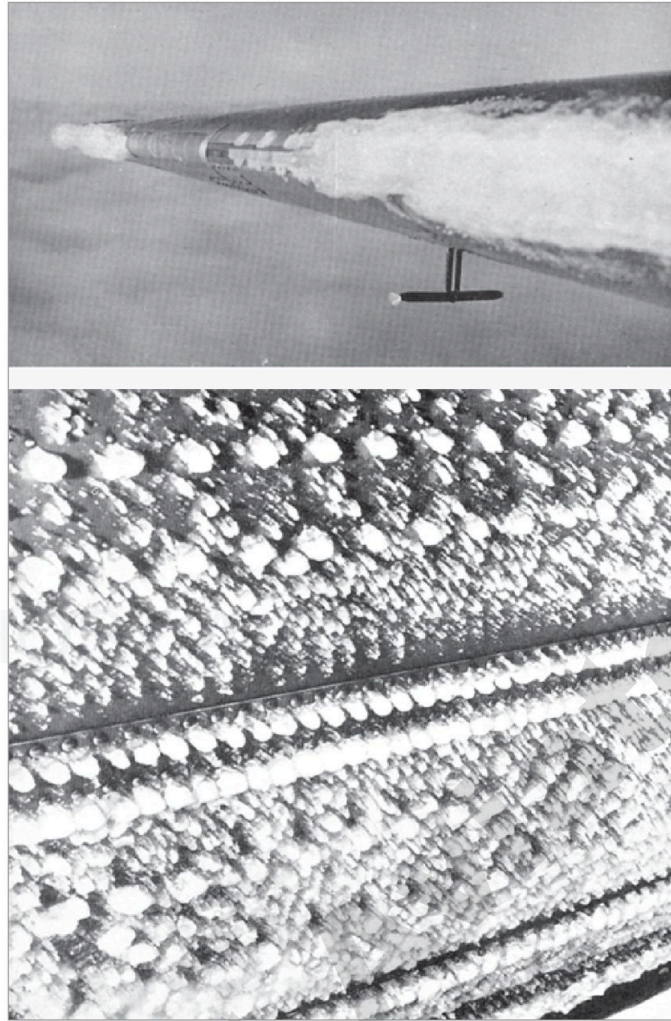
4. Effects of Airframe Icing

⚠ **Airframe icing affects flying characteristics in multiple ways:**

1. Alters **aerodynamics**, increases weight, and **decreases lift**
2. Increases the **stalling speed** appreciably
3. **Increases drag**
4. Unequal loading on propeller blades → **decreases efficiency** and effective power → vibrations
5. Hinges of ailerons, elevator and trimming tabs may get **jammed**
6. **ASI** may give erroneous readings due to icing of pitot tube
7. Icing on aerials may render **communication difficult**



Thin wing sections collect ice faster



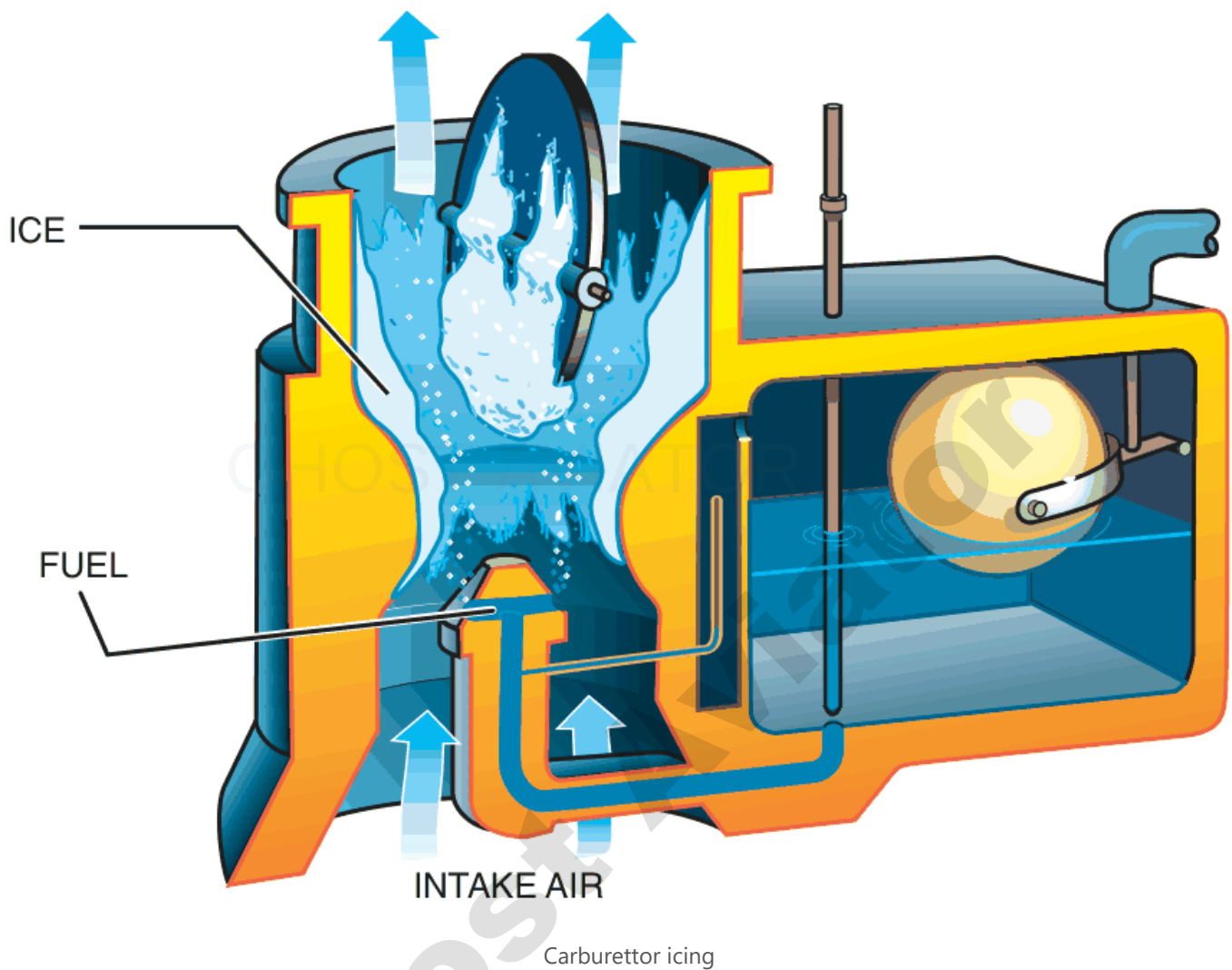
Ice on a tailplane and underwing

flowchart LR

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ICE[Ice Accretion] --> A[↑ Weight\n↓ Lift]
ICE --> B[↑ Stall Speed]
ICE --> C[↑ Drag]
ICE --> D[Propeller Vibration\n↓ Effective Power]
ICE --> E[Control Surface Jam\nAilerons / Elevator / Tabs]
ICE --> F[ASI Error\nPitot Icing]
ICE --> G[Comms Degraded\nAerial Icing]
  
```

5. Engine Icing



Impact Icing

Occurs due to the **impact of supercooled water drops on the air intake**. Icing restricts air inflow, which reduces engine power.

Carburetor Icing

When air passes through the carburetor choke and past the throttle butterfly, pressure falls → **adiabatic cooling** drops temperature to a very low value. This cooling is **further enhanced by evaporation of fuel**.

Types:

- Can occur in clear air at ambient temperature of **+30°C** if humidity is high (due to evaporative cooling).
- Below **-10°C**: this type of icing is **negligible** unless liquid water is present.
- Carburetor icing is **unlikely** when relative humidity is less than **60%**.

 **Exam Tip:** Carburetor icing can occur at ambient temperatures as high as **+30°C** — a common exam trap. It is NOT only a cold-weather phenomenon. The key is *high humidity + venturi cooling + fuel evaporation*.

6. Height of Freezing Level in India

In the North, Central, and Southern parts of India the Freezing Level occurs approximately at the pressure levels in various seasons:

Season	North	Central	South
NE Monsoon	700 hPa	600 hPa	600 hPa
Pre-Monsoon	650 hPa	600 hPa	550 hPa
SW Monsoon	550 hPa	500 hPa	500 hPa
Post Monsoon	550 hPa	600 hPa	650 hPa

 **Key pattern:** During SW Monsoon the freezing level is *highest* (lowest pressure = highest altitude) — especially in Central and South India at **500 hPa**. During NE Monsoon the freezing level is *lowest* in the North at **700 hPa** (lowest altitude, most likely to affect lower-level operations).

7. Quick Revision Summary

⚡ AMBER Quick Revision — Ice Accretion

- **Rime Ice:** Small drops, instant freeze, opaque, rough, porous, light — forms in stratiform clouds
- **Glaze/Clear Ice:** Large drops, spreads then freezes, transparent, hard, heavy, MOST HAZARDOUS
- **Hoar Frost:** Sublimation below 0°C in cloudless air — feathery crystals
- **Severe icing:** 0°C to -7°C | Moderate: -7°C to -12°C | Light: -12°C to -20°C | Very Light: -20°C to -40°C
- **Ci, Cs, Cc:** Negligible icing | **As, Ns:** Light-Moderate | **Cb/TCu:** Light-Severe (up to -20°C)
- **Carburetor icing:** Can occur at +30°C OAT; negligible below -10°C; unlikely if RH < 60%
- **ASI error** from pitot icing | **Stall speed increases** with icing
- **SW Monsoon:** Freezing level highest (500 hPa Central/South) | NE Monsoon: Lowest in North (700 hPa)

8. Practice Q&A

Q1. Hoar frost occurs on airframe in clear air when the temperature of airframe is:
(a) below the frost point (b) frost point (c) just above the frost point

✓ **Answer: (a) below the frost point**

Hoar frost forms by sublimation — water vapour deposits directly as ice when surface temperature is **BELOW** the frost point (dew point in sub-freezing conditions).

✗ (b) At the frost point — would just be at threshold, deposition is active below it. ✗ (c) Just above — no sublimation occurs above the frost point.

💡 Instructor's Note: Frost point = dew point at sub-zero temperatures. Surface must be colder than the surrounding air — classic for cold-soaked aircraft descending into humid layers.

Q2. In clouds at temperatures below 0°C an aircraft may encounter icing of the type:
(a) only Glazed (b) only Rime (c) intermediate between these two

✓ **Answer: (c) intermediate between these two**

In clouds below 0°C, a mix of supercooled water drop sizes and temperatures produces mixed ice — a combination of rime and glaze characteristics.

✗ (a) Only glazed — requires large supercooled drops specifically. ✗ (b) Only rime — requires small drops and very fast freezing.

💡 DGCA frequently asks about mixed icing in clouds — answer is nearly always "intermediate" or "mixture."

Q3. Opaque Rime ice is:
(a) Light porous (b) Solid (c) Mixture of porous and solid

✓ **Answer: (a) Light porous**

Rime ice traps air between small droplets during instantaneous freezing → opaque, rough, light, and porous structure.

✗ (b) Solid — describes glaze/clear ice. ✗ (c) Mixture — describes mixed ice.

💡 Rime = Rough, Milky, Light/porous. Glaze = Glossy, Hard, Heavy.

Q4. Rime is formed by freezing of supercooled water droplets on airframe when aircraft is flying through clouds:

(a) Small (b) Large (c) Medium

✅ **Answer: (a) Small**

Small droplets freeze instantly on contact → rime ice. Large droplets spread before freezing → glaze ice.

✗ (b) Large — produces glaze/clear ice. ✗ (c) Medium — produces intermediate/mixed ice.

💡 Drop size is the KEY differentiator: Small → Rime; Large → Glaze. This appears repeatedly in DGCA exams.

Q5. Glazed ice is formed by freezing of supercooled water droplets on airframe when aircraft is flying through clouds:

(a) Small (b) Large (c) Medium

✅ **Answer: (b) Large**

Large supercooled drops spread over the surface before freezing → clear/glaze ice.

✗ (a) Small → rime. ✗ (c) Medium → mixed.

💡 Paired with Q4 — remember the contrast.

Q6. The ice poses serious aviation hazard:

(a) Rime (b) Hoar Frost (c) Glazed

✅ **Answer: (c) Glazed**

Glaze/clear ice is the most hazardous — heavy, hard, alters aerodynamics, hard to remove, can break into dangerous lumps.

✗ (a) Rime — less hazardous, lighter, rough but less structurally damaging. ✗ (b) Hoar frost — mostly a takeoff/ground hazard.

💡 Exam favourite: "Most hazardous = Glaze/Clear ice."

Q7. Airframe icing occurs below 0°C. Its probability of occurrence decreases progressively below -20°C as at lower temperatures the proportion of supercooled water drops in a cloud:

(a) Increases (b) Decreases (c) Does not change

✅ **Answer: (b) Decreases**

Below -20°C, supercooled liquid water content drops sharply as more droplets spontaneously freeze into ice crystals → less liquid water → less icing.

✗ (a) Increases — opposite is true. ✗ (c) Does not change — incorrect.

💡 Below -40°C: virtually ALL water is ice crystals → negligible icing risk.

Q8. Ci, Cs and CC clouds consist mostly of ice crystals. Icing hazard is therefore:

(a) Maximum (b) Medium (c) Negligible

✅ **Answer: (c) Negligible**

High cloud types (Ci, Cs, Cc) are composed of ice crystals, not supercooled water drops → icing hazard is negligible.

✗ (a)(b) — incorrect; ice crystals don't adhere like supercooled droplets.

💡 No liquid water = no significant icing. Ice crystals simply bounce off the airframe.

Q9. As, NS consist of supercooled water drops and ice crystals in varying proportion icing is possible:

(a) Maximum (b) Light or moderate (c) Negligible

✓ **Answer: (b) Light or moderate**

Mixed-phase clouds (As, Ns) have both supercooled drops and ice crystals → light to moderate icing.

✗ (a) Maximum — reserved for CB/TCu near 0°C. ✗ (c) Negligible — not accurate as liquid water is present.

💡 As and Ns are associated with warm front / widespread precipitation — light to moderate icing over large areas.

Q10. In AC clouds icing is possible in mountainous areas:

(a) Light (b) Moderate (c) Severe

✓ **Answer: (c) Severe**

In mountainous areas, Ac clouds can develop strong updrafts and large supercooled water content → severe icing possible.

✗ (a)(b) — correct for flat terrain, but mountains enhance the icing severity.

💡 Mountains amplify icing in Ac. This is an exam trap — the standard answer for AC is "light to moderate" but "mountainous areas" → severe.

Q11. In TCu icing may range from light to severe type at least up to level:

(a) -40°C level (b) -30°C level (c) -20°C level

✓ **Answer: (c) -20°C level**

In TCu clouds, significant icing (light to severe) occurs up to the **-20°C** level. Above this, supercooled water content decreases.

✗ (a) -40°C — too deep; icing severity has already reduced significantly. ✗ (b) -30°C — not the correct threshold stated in the text.

💡 -20°C is the key threshold for icing severity in TCu and Cb. Memorise: **-20°C**.

Q12. In CB icing may range from light to severe type up to -20°C level. Below this temperature severe icing is:

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(a) not significant (b) significant (c) maximum

✅ Answer: (a) not significant

Below -20°C in Cb, liquid water content is much reduced → severe icing is not significant.

❌ (b)(c) — incorrect; supercooled drops are fewer below -20°C .

💡 Cb is dangerous for icing between 0°C and -20°C — the zone of maximum supercooled water content.

Q13. Liquid water content is an important factor in icing. As the maximum water concentration is around maximum ice formation in clouds may also be expected around that level:
(a) -25°C level (b) -20°C level (c) -15°C level

✅ Answer: (a) -25°C level

Maximum supercooled water concentration in clouds peaks around -25°C .

❌ (b) -20°C — close but not peak. ❌ (c) -15°C — warmer than peak.

💡 Tricky! Peak liquid water content $\approx -25^{\circ}\text{C}$; icing hazard peaks here despite being "colder" than you'd expect.

Q14. Carburetor icing occurs when air from intake passes through a venturi (choke) and causes expansional cooling and vaporization of fuel. Serious icing can occur at extreme temperatures:
(a) 13°C (b) 30°C to -10°C (c) 20°C

✅ Answer: (b) 30°C to -10°C

Carburetor icing can occur across a wide temperature range — from as warm as $+30^{\circ}\text{C}$ (with high humidity) to as cold as -10°C (below which it becomes negligible without liquid water).

❌ (a)(c) — single temperature values don't represent the range.

💡 $+30^{\circ}\text{C}$ to -10°C is the carburetor icing danger range. This is a classic DGCA question.

Q15. occurs in a moist cloudless air on an aircraft surface having temp. below 0°C , due to sublimation of water vapour onto feathery ice crystals:

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(a) Rime (b) Glazed (c) Hoar Frost

✅ **Answer: (c) Hoar Frost**

Hoar frost = sublimation of water vapour directly onto the cold surface as feathery ice crystals in clear air below 0°C.

❌ (a) Rime — forms in cloud, not cloudless air. ❌ (b) Glaze — requires liquid drops.

💡 Key phrase: "cloudless air + sublimation" = Hoar Frost.

Q16. occurs in St, Sc, Ac, Cu, Ns at temperature -10 to -40°C and in Cb at temperature -20 to -40°C:

(a) Rime (b) Glazed (c) Hoar Frost

✅ **Answer: (a) Rime**

Rime ice is associated with these cloud types in the temperature range **-10°C to -40°C** (St, Sc, Ac, Cu, Ns) and **-20°C to -40°C** (Cb).

❌ (b) Glaze — found closer to 0°C with large drops. ❌ (c) Hoar Frost — requires cloudless air.

💡 Rime dominates in the colder part of the icing range where drops are small and freeze instantly.

Q17. In clouds occurs when a wide range of water drop sizes are present at temperatures between 0°C and -40°C:

(a) Rime (b) Glazed and clear ice (c) Mixture of rime and clear ice

✅ **Answer: (c) Mixture of rime and clear ice**

When both large and small supercooled drops coexist (wide size range) between 0°C and -40°C, both rime and glaze/clear ice form simultaneously — mixed icing.

❌ (a) Rime only — requires exclusively small drops. ❌ (b) Glazed only — requires exclusively large drops.

💡 "Wide range of drop sizes" → Mixed icing. This tests understanding that rime and glaze don't always occur in isolation.

Q18. occurs in AS, NS, AC and towering CU or CB between 0°C and -20°C, in warm front below 0°C, if the aircraft has rapidly descended from a colder region:

(a) Glazed (b) Rime (c) Mixture of Rime and Clear ice

✅ **Answer: (c) Mixture of Rime and Clear ice**

In As, Ns, Ac, TCu, Cb between 0°C and -20°C — mixed drop sizes → mixed icing. Also in warm front scenarios where a cold-soaked aircraft descends into warmer moist air.

❌ (a) Glazed only — not exclusively. ❌ (b) Rime only — not exclusively.

💡 As/Ns/warm front conditions → Mixed ice. Temperature range **0°C to -20°C**.

Q19. When fog freezes on parked aircraft it produces

(a) Hoar Frost (b) Rime (c) Clear ice

✅ **Answer: (b) Rime**

Fog consists of small supercooled/freezing water droplets. When these freeze on a parked aircraft surface, they form rime ice (instantaneous freezing of small drops).

❌ (a) Hoar Frost — from water vapour sublimation, not liquid fog droplets. ❌ (c) Clear ice — requires large drops and spreading before freezing.

💡 Freezing fog → Rime on parked aircraft. Common de-icing scenario at cold airports.

Q20. Icing the stalling speed appreciably:

(a) Decreases (b) Increases (c) Does not increase/decrease

✅ **Answer: (b) Increases**

Ice deposits on wings alter the aerofoil shape, reduce lift generation, and increase the minimum speed needed to maintain lift — thus stall speed increases.

❌ (a) Decreases — opposite; icing degrades aerodynamic efficiency. ❌ (c) No effect — incorrect; icing always degrades performance.

💡 Key safety point: With icing, approach speeds must be INCREASED to maintain margin above the higher stall speed.

GHOST AVIATOR

Ghost Aviator

GHOST AVIATOR

9. Master Reference Tables

All Numerical Values

Parameter	Value
Severe icing temperature range	0°C to -7°C
Moderate icing temperature range	-7°C to -12°C
Light icing temperature range	-12°C to -20°C
Very light icing temperature range	-20°C to -40°C
Peak supercooled water concentration	-25°C
TCu/Cb icing (light to severe) up to	-20°C
Carburetor icing can occur up to	+30°C OAT
Carburetor icing negligible below	-10°C
Carburetor icing unlikely if RH below	60%
NE Monsoon freezing level North	700 hPa
SW Monsoon freezing level Central/South	500 hPa
Rime in St/Sc/Ac/Cu/Ns (temp range)	-10°C to -40°C
Rime in Cb (temp range)	-20°C to -40°C
CB icing zone (0°C to -20°C level)	Light to Severe

Mnemonics

- **RIME** = Rough, Instant, Milky/opaque, Easy to form (small drops)
- **GLAZE** = Glossy, Large drops, Alters aerodynamics severely, Zones of spreading, Extra hazardous
- **Severity order** (warmest → coldest): Severe (0 to -7) → Moderate (-7 to -12) → Light (-12 to -20) → Very Light (-20 to -40)
- **Carb icing range**: "+30 to -10" — thirty to minus ten
- **Ci, Cs, Cc** = Ice crystals = negligible icing ("HIGH = harmless")
- **SW Monsoon** = Highest freezing level (500 hPa = highest altitude)