

C-20 HVAC Contractor

Solution key

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1. An air conditioner has 2,400 watts of electrical input and 24,000 BTU/h of cooling. What is the EER of this system?

- A. 2.4
- B (correct). 10.0**
- C. 9.0
- D. 12.0

Rationale: EER (Energy Efficiency Ratio) = BTU/h ÷ Watts = 24,000 ÷ 2,400 = 10.0. Higher EER values indicate more efficient systems.

2. Hydrofluoric acid can be formed when HFC refrigerants are exposed to:

- A. Water or humidity
- B. Contact with copper tubing
- C (correct). Open flames or very high temperatures**
- D. Ultraviolet light

Rationale: HFC refrigerants thermally decompose when exposed to open flames or very high temperatures, producing hydrofluoric acid — an extremely dangerous acid that can cause severe burns and systemic toxicity.

3. Which factor most significantly increases the cooling load in a building with large south-facing windows?

- A. North-facing roof color
- B. Internal heat from occupants
- C (correct). Solar heat gain through south-facing windows**
- D. Duct leakage from the supply system

Rationale: South-facing windows in California receive significant direct solar radiation, especially in summer. Solar heat gain through glass is often the largest single component of a residential cooling load.

4. When installing a gas furnace, the flue vent pipe must slope toward the furnace at a minimum grade of:

- A (correct). 1/4 inch per foot sloping upward toward the chimney**
- B. 2 inches per foot upward
- C. 1 inch per foot downward toward the furnace
- D. Level — no slope required

Rationale: Gas appliance vent pipes must slope upward from the appliance to the chimney at minimum 1/4 inch per foot to allow condensate to drain back to the appliance and prevent backdrafting.

5. In duct design, the "available static pressure" for the duct system is calculated as:

- A. Fan motor horsepower divided by airflow
- B. Total external static pressure plus component drops
- C (correct). Total external static pressure minus the pressure drop of all components**
- D. Supply pressure minus return pressure

Rationale: Available static pressure = Total external static pressure of the air handler minus the pressure drop of all components (coil, filter, diffusers). This is what remains to overcome duct friction.

6. A change order in HVAC contracting is used when:

- A (correct). Document changes to the original scope, price, and schedule before work begins**
- B. Inform the customer of project progress
- C. Record warranty information for installed equipment
- D. Order additional materials from suppliers

Rationale: A change order documents changes to the original scope of work, including additions, deletions, or substitutions, and establishes the adjusted price and schedule before work begins.

7. A technician measures 20°F of superheat at the evaporator outlet of an R-410A system. This indicates:

- A. Overcharge — liquid flooding the compressor
- B (correct). Normal — evaporator is fully active and compressor is protected**
- C. Severe undercharge requiring refrigerant
- D. TXV is stuck closed

Rationale: Superheat of 20°F at the evaporator outlet is within the normal range of 10–20°F for most TXV-controlled systems. It confirms the evaporator is fully active and the compressor is protected from liquid slugging.

8. What is the purpose of a heat gain calculation for an existing building?

- A (correct). Determine actual cooling load to right-size replacement equipment**
- B. Estimate the age of the existing system
- C. Document original installation records
- D. Calculate the original equipment warranty period

Rationale: Heat gain calculations for existing buildings determine the actual cooling load — which may differ from original design due to renovations, occupancy changes, or equipment additions — to right-size replacement equipment.

9. A packaged water source heat pump eliminates which component compared to a split system?

- A. Evaporator
- B (correct). Air-cooled condenser**
- C. Reversing valve
- D. Capacitor

Rationale: A packaged water source heat pump uses water as the heat exchange medium, eliminating the need for an outdoor air-cooled condenser. All components are contained in one cabinet.

10. Proper electrical safety when working on HVAC equipment requires testing for voltage with a multimeter before touching wires. This is done to:

- A (correct). Verify circuits are de-energized with a multimeter — capacitors can store lethal charge**
- B. Assume circuits are de-energized if the disconnect is open
- C. Test only after all power to the building is disconnected
- D. Use rubber gloves only, no testing needed

Rationale: Always verify with a multimeter that circuits are de-energized before touching conductors, even after turning off a disconnect — capacitors can store lethal charge and misidentified circuits can remain energized.

11. Zoning systems in residential HVAC use which primary control mechanism?

- A. Separate gas valves for each zone
- B (correct). Motorized dampers controlled by individual zone thermostats**
- C. Multiple air handlers with separate refrigerant circuits
- D. A central thermostat controlling all zones simultaneously

Rationale: Zoning systems use motorized dampers in the duct system — typically controlled by individual zone thermostats — to direct conditioned air only to zones that call for heating or cooling.

12. Refrigerant cylinders must be stored:

- A. In enclosed vehicles when not in use
- B (correct). Upright, secured, away from heat sources, in ventilated areas**
- C. On their sides in direct sunlight for accessibility
- D. Near the work area for convenience

Rationale: Refrigerant cylinders must be stored upright (valve end up), secured to prevent tipping, away from heat sources and flames, and in ventilated areas. They must never be stored in direct sunlight.

13. A condensate overflow switch (float switch) is installed to:

- A. Measure condensate flow rate
- B. Regulate refrigerant flow
- C. Filter condensate before it drains
- D (correct). Shut off the system when the condensate drain pan fills due to a clogged drain**

Rationale: The condensate overflow float switch shuts off the system when the condensate drain pan fills up due to a clogged drain line, preventing water damage to the air handler and ceiling below.

14. Cal/OSHA requires fall protection for workers on roofs at heights of:

- A. 6 feet
- B. 4 feet
- C. 10 feet
- D (correct). 7.5 feet**

Rationale: Cal/OSHA requires fall protection (guardrails, personal fall arrest systems, or safety nets) for employees on roofs at heights of 7.5 feet or more above a lower level.

15. California's Title 24 Building Energy Efficiency Standards primarily affect HVAC contractors by requiring:

- A (correct). Minimum efficiency ratings, duct sealing/insulation, and commissioning documentation**
- B. Only choosing aesthetically pleasing equipment
- C. Filing paperwork with the state after installation
- D. Using only California-manufactured equipment

Rationale: Title 24 mandates minimum equipment efficiency ratings (SEER2, HSPF2, AFUE), proper duct sealing and insulation (duct leakage testing), and commissioning documentation for new and replacement systems.

16. Manual S is used in HVAC system design to:

- A. Analyze psychrometric properties of air
- B. Calculate commercial loads
- C (correct). Select equipment whose performance matches Manual J design loads**
- D. Design duct systems

Rationale: ACCA Manual S (Residential Equipment Selection) provides procedures for selecting HVAC equipment whose performance matches the design loads calculated in Manual J, ensuring proper capacity and humidity control.

17. Which ACCA manual is used for residential load calculations?

- A (correct). Manual J
- B. Manual D
- C. Manual N
- D. Manual S

Rationale: Manual J (Residential Load Calculation) published by the Air Conditioning Contractors of America (ACCA) is the industry-standard method for calculating heating and cooling loads for residential buildings.

18. The minimum slope required for a condensate drain line is:

- A. 1 inch per foot
- B (correct). 1/8 inch per foot toward the drain
- C. 2 inches per foot
- D. Level — no slope required

Rationale: Condensate drain lines must slope a minimum of 1/8 inch per foot (1% grade) toward the drain point to ensure gravity flow and prevent standing water.

19. A zoning system with multiple dampers causes excessive noise from one zone when others are closed. The most likely cause is:

- A. The return duct is oversized
- B (correct). All airflow forced through open zone increases velocity — bypass damper or variable-speed unit needed
- C. The air handler is too small
- D. The thermostat is wired incorrectly

Rationale: When dampers close in other zones, all system airflow is forced through the open zone, dramatically increasing duct velocity and creating noise. A bypass damper or variable-speed air handler is needed.

20. What is the purpose of a condensate trap on a forced-air cooling system?

- A (correct). Prevent negative pressure from siphoning air through the condensate drain
- B. Filter drain water from the condensate pan
- C. Reduce vibration in the condensate drain line
- D. Collect refrigerant that leaks from the evaporator coil

Rationale: A condensate trap prevents negative pressure in the air handler from siphoning air through the condensate drain, which would bypass the drain and allow humid air into the system.

21. The ASHRAE Handbook — Fundamentals is primarily referenced by HVAC contractors for:

- A. Refrigerant recovery procedures
- B. California licensing requirements
- C. Equipment installation procedures
- D (correct). Scientific foundation including thermodynamics, psychrometrics, and heat transfer

Rationale: The ASHRAE Fundamentals Handbook provides the scientific and engineering foundation for HVAC design including thermodynamics, psychrometrics, heat transfer, fluid mechanics, and energy use.

22. A contractor is estimating a commercial HVAC job. The equipment cost is \$42,000 and labor is estimated at \$18,000. If overhead is 15% and profit is 10% of total costs, what is the bid price?

- A. \$72,000
- B (correct). \$75,900
- C. \$69,000
- D. \$78,000

Rationale: Total direct cost = \$60,000. Overhead = 15% × \$60,000 = \$9,000. Subtotal = \$69,000. Profit = 10% × \$69,000 = \$6,900. Bid price = \$75,900.

23. SMACNA standards govern the fabrication of which HVAC components?

- A. Refrigerant handling procedures
- B. Electrical wiring of HVAC equipment
- C (correct). Fabrication, installation, and testing of sheet metal duct systems**
- D. Equipment efficiency testing standards

Rationale: SMACNA (Sheet Metal and Air Conditioning Contractors' National Association) standards govern the fabrication, installation, and testing of sheet metal duct systems.

24. A heat pump in heating mode is not achieving adequate capacity. The outdoor coil is covered with a heavy layer of ice. The most likely cause is:

- A. Thermostat set too low
- B. Low refrigerant charge
- C (correct). Defrost control failure**
- D. Outdoor temperature too high

Rationale: Heavy ice buildup on the outdoor coil in heating mode (when it acts as the evaporator) is usually caused by a defrost control failure — the system is not initiating defrost cycles properly.

25. An air conditioning system is running but not cooling. The technician measures normal suction pressure but high head pressure. The most likely cause is:

- A. Oversized evaporator coil
- B. Low refrigerant charge
- C (correct). Dirty condenser coils restricting airflow**
- D. Stuck-open TXV

Rationale: High head pressure with normal suction pressure indicates a condenser-side problem — typically dirty condenser coils restricting airflow, which prevents proper heat rejection and causes high condensing pressure.

26. When using a brazing torch near combustible materials, which precaution is required?

- A. Turn off the gas supply to the building
- B (correct). Maintain a fire watch during and for 30 min after brazing with a fire extinguisher available**
- C. No special precautions needed for torch work
- D. Only use fire watch for outdoor brazing

Rationale: A fire watch must be maintained during and for at least 30 minutes after brazing near combustible materials. A fire extinguisher must be readily available and combustibles should be removed or shielded.

27. What is the correct sequence for commissioning a newly installed split system air conditioner?

- A (correct). Verify charge and pressures, electrical amperage, airflow, temperatures, and document all readings**
- B. Turn on the system and leave if no error codes appear
- C. Set the thermostat and leave the customer a manual
- D. Check refrigerant charge only and sign off

Rationale: Proper commissioning sequence: verify refrigerant charge and pressures, check electrical connections and amperage draws, measure supply and return air temperatures, verify airflow, and document all readings.

28. How often should air filters in a residential HVAC system typically be replaced?

- A. Every 5 years
- B. Once a year
- C (correct). Every 1–3 months depending on type and conditions**
- D. Only when the system stops working

Rationale: Standard 1-inch filters should be replaced every 1–3 months depending on filter type, household dustiness, and pet ownership. Dirty filters restrict airflow, reduce efficiency,

and can cause system damage.

29. California Title 24 requires new duct systems and replacement systems to pass a duct leakage test. The maximum allowable duct leakage for new systems is:

- A. 15% of system airflow
- B. 25% of system airflow
- C. No leakage limit for new systems
- D (correct). 5% of system airflow**

Rationale: California Title 24, Section 150.0(m) requires that new duct systems achieve a verified total leakage of not more than 5% of system airflow (5% leakage to outside in most cases).

30. When handling liquid R-410A from a cylinder, the risk of freeze burns is because:

- A. R-410A is too warm to cause burns
- B. Liquid refrigerant only causes irritation, not burns
- C (correct). Liquid R-410A rapidly freezes (cryogenic burn) exposed skin at its -61°F boiling point**
- D. R-410A causes chemical burns not freeze burns

Rationale: R-410A has a boiling point of approximately -61°F at atmospheric pressure. Contact with liquid R-410A causes rapid freezing (cryogenic burns) of exposed skin.

31. When working with R-410A refrigerant, which PPE must be worn?

- A (correct). Safety glasses and insulated gloves to protect against refrigerant burns**
- B. No PPE required for small cylinders
- C. Hearing protection only
- D. Full face shield and fire-resistant clothing only

Rationale: R-410A is stored at high pressure. Safety glasses and insulated gloves must be worn when handling R-410A to protect against refrigerant burns from rapid depressurization and contact with liquid refrigerant.

32. In a duct system, a plenum is:

- A. A type of outdoor condensing unit
- B (correct). The air distribution chamber connected to the air handler**
- C. A type of HVAC filter
- D. A chemical used to seal duct joints

Rationale: A plenum is the air distribution chamber connected directly to the air handler that distributes conditioned air to the supply duct branches or collects return air from the space.

33. What is the purpose of a Manual N calculation?

- A (correct). Commercial building load calculations**
- B. Residential duct design
- C. Residential equipment selection
- D. Psychrometric analysis

Rationale: ACCA Manual N (Commercial Load Calculation) provides procedures for calculating heating and cooling loads in commercial buildings using block or room-by-room methods.

34. To measure the refrigerant charge using the superheat method, a technician needs:

- A. Ambient temperature and thermostat setting
- B. Only suction line temperature
- C (correct). Suction line temperature and suction pressure (to find saturation temperature)**
- D. Discharge pressure and liquid line temperature

Rationale: The superheat method requires measuring suction line temperature and suction pressure (to determine saturation temperature). Superheat = actual suction line temperature minus saturation temperature at suction pressure.

35. An HVAC technician discovers a refrigerant leak. Under EPA Section 608, what action must be taken?

- A (correct). Repair leaks within 30 days if leak rate exceeds applicable threshold**
- B. Vent the refrigerant and recharge
- C. No action is required for leaks under 50 lbs
- D. Report the leak to the EPA within 24 hours only

Rationale: EPA Section 608 regulations require that refrigerant leaks in systems with more than 50 lbs of charge must be repaired within 30 days if the leak rate exceeds the applicable threshold.

36. Under California law, releasing refrigerant intentionally into the atmosphere is:

- A (correct). Illegal — prohibited by EPA Section 608 and California law with fines up to \$37,500/day**
- B. Legal if the system is being decommissioned
- C. Legal for small quantities under 5 lbs
- D. Legal if the refrigerant is R-22 only

Rationale: California Health and Safety Code and EPA Section 608 prohibit the intentional venting of refrigerants. Violations can result in fines up to \$37,500 per day per violation.

37. A heat pump has a COP of 3.5 in heating mode. This means:

- A. The system efficiency is 35%
- B. The heat pump requires 3.5 tons of capacity
- C. The heat pump uses 3.5 times more electricity than a resistance heater
- D (correct). The heat pump delivers 3.5 units of heat for every 1 unit of electricity consumed**

Rationale: COP (Coefficient of Performance) in heating mode = heat delivered ÷ electrical energy consumed. COP of 3.5 means the heat pump delivers 3.5 units of heat for every 1 unit of electricity consumed.

38. A cooling load calculation must account for heat gain from which of the following sources?

- A. Duct leakage only
- B. Outdoor temperature only
- C. Refrigerant charge only
- D (correct). Solar gain, conduction, internal gains, and infiltration**

Rationale: Cooling load calculations per ACCA Manual J must include solar heat gain through windows, heat conducted through walls and roof, internal heat from occupants and equipment, and infiltration and ventilation loads.

39. A thermocouple in a gas furnace is a safety device that:

- A. Safety device that controls the thermostat
- B (correct). Safety device that confirms the existence of a pilot flame**
- C. Safety device for electronic ignition
- D. Safety control for the fan

Rationale: A thermocouple generates a small electrical current when heated by the pilot flame. This current holds the gas valve open. If the pilot goes out, the thermocouple cools and the gas valve closes automatically.

40. A gas furnace has a cracked heat exchanger. The primary safety concern is:

- A. Increased gas consumption only
- B. Fan motor overheating
- C (correct). Carbon monoxide mixing with supply air — a life-threatening hazard**
- D. Minor efficiency loss only

Rationale: A cracked heat exchanger allows combustion gases — including deadly carbon monoxide — to mix with the circulating supply air, creating a carbon monoxide poisoning hazard for building occupants.

41. A gas furnace blower runs but no heat is produced. The inducer motor is running and ignition is attempted but no flame is established. The most likely cause is:

- A. Failed inducer motor
- B. Cracked heat exchanger
- C. Incorrect thermostat wiring

D (correct). Failed igniter, no gas supply, or gas valve not opening

Rationale: If ignition is attempted but no flame is established, the likely causes are: failed igniter (cracked or burned out), no gas supply, gas valve not opening, or failed spark ignition module.

42. What is the design heating load used for in HVAC system sizing?

- A. Determine the annual fuel usage of the system
- B. Calculate the duct airflow requirements
- C. Size the gas supply line to the furnace

D (correct). Determine the minimum heating capacity to maintain comfort during coldest conditions

Rationale: The design heating load determines the minimum heating capacity (BTU/h) required to maintain indoor comfort conditions during the coldest expected outdoor conditions at the building location.

43. The Global Warming Potential (GWP) of a refrigerant is a concern for California contractors because:

- A. High GWP refrigerants are incentivized by the state
- B (correct). California CARB regulations target high-GWP refrigerants requiring transition to lower-GWP alternatives**
- C. GWP only affects residential systems
- D. Federal regulations preempt all California GWP rules

Rationale: California CARB regulations and HFC reduction mandates target refrigerants with high GWP. Contractors must transition to lower-GWP alternatives to comply with California's climate regulations.

44. An evaporator coil is freezing up during normal operation. The most likely causes include:

- A (correct). Dirty filter, low refrigerant charge, or low ambient temperatures**
- B. Oversized system running continuously
- C. High outdoor temperature
- D. High indoor humidity only

Rationale: Evaporator coil freeze-up is caused by insufficient airflow (dirty filter, closed registers, failed blower), low refrigerant charge, or low ambient temperatures causing suction pressure to drop below freezing.

45. When brazing refrigerant lines, nitrogen should be flowed through the tubing to prevent:

- A. The refrigerant from escaping
- B (correct). Formation of copper oxide scale inside the tubing**
- C. The flame from extinguishing
- D. Moisture from entering the system

Rationale: Flowing dry nitrogen through copper tubing during brazing prevents the formation of copper oxide scale (also called "black scale") inside the tubing, which can contaminate the refrigerant circuit.

46. When installing a split system, the lineset should be run with the suction line:

- A (correct). On the bottom, insulated separately, with the liquid line on top**
- B. Buried underground for protection
- C. Bundled together with the liquid line, no insulation needed
- D. On top, with the liquid line below

Rationale: The suction line (larger diameter, cold) should be on the bottom when running vertically and insulated separately. The liquid line (smaller) goes on top. Both should be protected from physical damage.

47. What is "acid burnout" in a refrigerant compressor?

- A. Refrigerant reacting with copper tubing
- B. Overheating of the compressor discharge
- C (correct). Moisture reacting with refrigerant and oil to form acids that damage compressor windings**
- D. Excessive voltage burning out motor windings

Rationale: Acid burnout occurs when moisture enters the refrigerant circuit and reacts with refrigerant and oil to form hydrofluoric and hydrochloric acids, which damage compressor windings and contaminate the system.

48. What does the term "sensible heat ratio" (SHR) represent in HVAC design?

- A. Total load ÷ equipment capacity
- B. Latent load ÷ sensible load
- C (correct). Sensible load ÷ total load**
- D. Cooling capacity ÷ electrical input

Rationale: The sensible heat ratio is the fraction of total heat gain that is sensible (dry) heat versus latent (moisture) heat. $SHR = \text{Sensible Load} \div \text{Total Load}$. It determines the required coil performance.

49. During startup of a new air conditioning system, a technician measures subcooling at the condenser outlet. Proper subcooling for most systems is:

- A. Subcooling should be zero
- B. 30–40°F
- C. 0–5°F
- D (correct). 10–20°F for most systems**

Rationale: Proper subcooling typically ranges from 10–20°F for most systems. Subcooling ensures the refrigerant is fully condensed before the TXV, preventing flash gas and ensuring proper metering.

50. The suction line of a split air conditioning system should be sized to:

- A. Be as small as possible to increase velocity
- B. Match the liquid line diameter exactly
- C. Be sized for the total system BTU only
- D (correct). Minimize pressure drop while maintaining sufficient velocity for oil return**

Rationale: The suction line must be large enough to minimize pressure drop (which reduces capacity and efficiency) but small enough to maintain sufficient refrigerant velocity to return oil to the compressor.

51. Under CSLB regulations, a C-20 contractor must not perform work that exceeds the scope of their license. Work that exceeds \$500 in combined labor and materials and is outside the HVAC scope requires:

- A. A general contractor to oversee the work
- B. Permission from the property owner
- C (correct). A separate license classification for the out-of-scope work**
- D. A C-20 can perform any construction work

Rationale: CSLB regulations require a separate license classification for work outside the licensed scope. Performing work outside the licensed classification is grounds for disciplinary action and criminal penalties.

52. Asphyxiation is a hazard when working in confined spaces with high concentrations of refrigerant because:

- A. Refrigerant burns when mixed with air
- B (correct). Refrigerants are heavier than air and displace oxygen causing deficiency**
- C. Refrigerant reacts with oxygen to form toxic compounds
- D. Refrigerant is toxic at any concentration

Rationale: Refrigerants are heavier than air and displace oxygen in enclosed spaces. High

concentrations can cause oxygen deficiency, leading to unconsciousness and asphyxiation without warning.

53. When estimating a duct system, the equivalent length method accounts for:

- A (correct). Converts fittings into equivalent lengths of straight duct based on pressure drop**
- B. Determines duct insulation requirements
- C. Measures actual duct length only
- D. Calculates airflow velocity

Rationale: The equivalent length method converts fittings, elbows, and transitions into equivalent lengths of straight duct based on their pressure drop, allowing a single friction rate to be used for the entire duct run.

54. When working in an attic during summer in California, heat illness prevention requires:

- A. Have employees drink only sports drinks
- B. Work only in the early morning hours
- C. No special precautions needed for short-duration attic work
- D (correct). Provide water, shade, and rest periods per Cal/OSHA regulations**

Rationale: Cal/OSHA Heat Illness Prevention Standard (Title 8, Section 3395) requires employers to provide water, shade, and rest periods for outdoor workers and workers in hot indoor environments like attics.

55. An older R-22 system requires refrigerant but R-22 is being phased out. Per EPA regulations, a technician may:

- A. Convert the system to R-410A without any modifications
- B (correct). Use only reclaimed or recycled R-22 to service existing systems**
- C. Vent the remaining R-22 and use a different refrigerant
- D. Purchase new R-22 from manufacturers

Rationale: As of January 1, 2020, R-22 production and import is banned. However, reclaimed or recycled R-22 may still be used to service existing systems. New R-22 equipment cannot be manufactured.

56. Manual D is the ACCA reference used for designing which component of an HVAC system?

- A. Equipment selection
- B (correct). Residential duct system design**
- C. Psychrometric analysis
- D. Load calculations

Rationale: ACCA Manual D provides the procedures for designing residential duct systems, including sizing supply and return ducts, calculating friction rates, and laying out duct routes.

57. What is the primary purpose of a psychrometric chart in HVAC system design?

- A. Calculate refrigerant charge
- B. Determine duct sizing
- C. Measure static pressure in duct systems
- D (correct). Graphically represent the properties of moist air**

Rationale: Psychrometric charts graphically represent the properties of moist air — temperature, humidity, enthalpy, dew point, and specific volume — allowing engineers to analyze air conditioning processes.

58. A contractor discovers that the actual job cost exceeds the original estimate by 20%. The most likely cause is:

- A. Equipment was higher quality than estimated
- B (correct). Inaccurate takeoffs, omissions, scope changes not covered by change orders, or unforeseen conditions**
- C. Labor was more efficient than expected
- D. The customer added extra rooms

Rationale: Cost overruns are most commonly caused by inaccurate quantity takeoffs, omissions in the original estimate, scope changes not covered by change orders, or unforeseen field conditions.

59. The California Mechanical Code requires that flexible duct connectors used to connect equipment to the duct system must not exceed what maximum length?

- A. 6 inches
- B. No limit specified
- C (correct). 14 inches**
- D. 36 inches

Rationale: California Mechanical Code and SMACNA standards limit flexible duct connectors at equipment to 14 inches maximum to minimize pressure drop and prevent sagging.

60. A refrigerant recovery machine must be used before opening any refrigerant circuit. This is required by:

- A (correct). EPA Section 608 of the Clean Air Act**
- B. Local fire department regulations
- C. Cal/OSHA Title 8
- D. ASHRAE Standard 15

Rationale: EPA Section 608 of the Clean Air Act requires technicians to recover refrigerant from systems before opening circuits for service, repair, or disposal. Venting is illegal.

61. When sizing a residential gas furnace, the output BTU/h capacity should be:

- A. Be selected based on the previous equipment size
- B. Exactly match the calculated load
- C (correct). Not exceed 125–140% of the calculated design heating load**
- D. Be at least 200% of the calculated load for safety

Rationale: Furnace output capacity should not exceed 125–140% of the calculated design heating load per ACCA Manual S equipment selection guidelines to prevent short-cycling and comfort issues.

62. Return air ducts in a residential HVAC system should be sized to maintain a maximum velocity of approximately:

- A. 1,500–2,000 FPM for maximum efficiency
- B. As high as possible to move maximum air
- C. 100–200 FPM only
- D (correct). 600–900 FPM to minimize noise**

Rationale: Return air ducts should be sized for velocities of 600–900 FPM to minimize noise. High return air velocity causes excessive noise at grilles and increases system static pressure.

63. California requires all HVAC contractors to carry workers' compensation insurance when they:

- A. Workers' compensation is optional for contractors
- B. Have 10 or more full-time employees
- C. Have annual payroll over \$500,000
- D (correct). Employ one or more workers — even part-time**

Rationale: California law (Labor Code 3700) requires all contractors who employ one or more workers — even part-time — to carry workers' compensation insurance. Failure to do so is a criminal offense.

64. What is the purpose of a filter dryer in a refrigerant circuit?

- A. Measure system superheat
- B. Prevent refrigerant migration during off cycles
- C. Regulate refrigerant flow to the evaporator
- D (correct). Remove moisture and contaminants from the refrigerant circuit**

Rationale: A filter dryer removes moisture and contaminants from the refrigerant circuit. Moisture in refrigerant systems causes acid formation, copper plating, and compressor damage.

65. An HVAC system installed in California must comply with which code for mechanical equipment?

- A. ASHRAE Standard 90.1 only
- B. SMACNA standards only
- C (correct). The California Mechanical Code (Title 24, Part 4)**
- D. International Mechanical Code without amendments

Rationale: The California Mechanical Code (Title 24, Part 4) governs all mechanical system installations in California, including HVAC equipment, ductwork, and ventilation requirements.

66. California requires HVAC installations to be inspected and permitted. Who is responsible for obtaining the permit?

- A. The local utility company
- B. The equipment manufacturer
- C (correct). The licensed contractor**
- D. The homeowner

Rationale: Under California Business and Professions Code and the California Mechanical Code, the licensed contractor is responsible for obtaining all required permits before beginning work.

67. California Title 24 energy standards require HVAC systems to meet minimum efficiency ratings. What does SEER2 measure?

- A. Energy factor of gas furnaces
- B. Static pressure ratio of duct systems
- C (correct). Cooling efficiency of A/C and heat pumps over a typical cooling season**
- D. Heating efficiency over a season

Rationale: SEER2 (Seasonal Energy Efficiency Ratio 2) measures the cooling efficiency of air conditioners and heat pumps over a typical cooling season under updated test conditions. Higher SEER2 = more efficient.

68. The subcooling method for checking refrigerant charge is most reliable for systems with:

- A. All systems equally
- B. Fixed orifice (piston) systems
- C (correct). Systems with TXVs (thermostatic expansion valves)**
- D. Systems with capillary tubes only

Rationale: The subcooling method is most reliable for systems with TXVs (thermostatic expansion valves), which maintain constant superheat. It measures temperature at the liquid line relative to condensing saturation temperature.

69. What is the most common cause of compressor failure in residential HVAC systems?

- A (correct). Liquid refrigerant or oil entering the compressor**
- B. Dirty condenser coils
- C. Excessive suction pressure
- D. Failed contactor

Rationale: Liquid slugging — liquid refrigerant or oil entering the compressor — is a leading cause of compressor failure. It is caused by low superheat, refrigerant migration during off cycle, or flooded starts.

70. Under Cal/OSHA, an employer must provide a written Injury and Illness Prevention Program (IIPP) that includes:

- A (correct). Hazard identification and correction, employee communication, training, and recordkeeping**
- B. A form filed annually with Cal/OSHA

- C. Equipment inspection logs only
- D. Insurance policy requirements

Rationale: Cal/OSHA Title 8 Section 3203 requires all California employers to have a written IIPP covering hazard identification and correction, employee communication, training, and recordkeeping.

71. When troubleshooting a system with a suspected refrigerant leak, an electronic leak detector should be used. The probe should be placed:

- A. In the return air stream
- B. At the highest point in the room
- C (correct). At the lowest point around fittings and coils where vapors accumulate**
- D. At the suction service valve only

Rationale: Refrigerant vapors are heavier than air. The probe should be placed at the lowest point around fittings, coils, and connections where refrigerant vapors will accumulate.

72. After installing a new refrigerant system, a vacuum must be pulled to remove moisture and non-condensables. The system should be evacuated to a minimum of:

- A. 5,000 microns
- B. 1 inch of mercury vacuum
- C. 29.9 inches Hg
- D (correct). 500 microns or less**

Rationale: The industry standard is to evacuate refrigerant systems to 500 microns (0.5 millitorr) or less, measured with an electronic micron gauge, before charging with refrigerant.

73. What refrigerant is required for new residential air conditioning equipment as of January 1, 2025 per California regulations?

- A. R-407C
- B (correct). R-32 and R-454B (lower GWP alternatives)**
- C. R-22
- D. R-134a

Rationale: California's Advanced Clean Air regulations and EPA Significant New Alternatives Policy (SNAP) phase out R-410A in new equipment. R-32 and R-454B (lower GWP alternatives) are the primary replacements for new residential systems.

74. What is the OSHA permissible exposure limit (PEL) for carbon monoxide in the workplace?

- A. 5 ppm
- B (correct). 50 ppm as an 8-hour time-weighted average**
- C. 200 ppm
- D. 500 ppm

Rationale: OSHA's PEL for carbon monoxide (CO) is 50 parts per million (ppm) as an 8-hour time-weighted average. CO is odorless and colorless — technicians must use CO detectors when working near combustion equipment.

75. Lockout/tagout (LOTO) procedures are required before:

- A. After completing all work on the system
- B (correct). Before any servicing where unexpected energization could cause injury**
- C. Only when working on gas appliances
- D. Only for systems over 480V

Rationale: LOTO procedures must be performed before any servicing or maintenance where unexpected energization, startup, or release of stored energy could cause injury — including working on electrical HVAC equipment.

76. What is the minimum clearance required between a condensing unit and a solid fence or wall per standard installation practice?

- A. 6 inches on all sides
- B (correct). 24 inches on discharge side, 12 inches on inlet sides**
- C. 48 inches on all sides
- D. No clearance required if the unit is a mini-split

Rationale: A minimum of 24 inches (2 feet) clearance on the air discharge side and 12 inches on the inlet sides is typically required for proper airflow and serviceability of an air-cooled condensing unit.

77. Under EPA Section 608, technicians who purchase refrigerants in containers larger than 2 pounds must be:

- A (correct). Be certified by an EPA-approved organization**
- B. Complete 40 hours of safety training
- C. Hold a contractor's license only
- D. Anyone can purchase refrigerant in any quantity

Rationale: EPA Section 608 of the Clean Air Act requires technicians who purchase or work with refrigerants in containers over 2 pounds to be certified by an EPA-approved organization.

78. A gas furnace ignites but immediately shuts off on the first call for heat. The most likely cause is:

- A (correct). Dirty or failed flame sensor**
- B. Failed inducer motor
- C. Incorrect thermostat setting
- D. Cracked heat exchanger

Rationale: If the furnace ignites and immediately shuts off, the flame sensor is most likely dirty or failed. The control board does not receive a flame signal and shuts the gas valve within seconds for safety.

79. An HVAC system has adequate airflow and refrigerant charge but the customer complains of high humidity in the structure. The most likely cause is:

- A. The TXV is stuck open
- B (correct). Oversized system short-cycles and does not run long enough to remove latent heat**
- C. The evaporator coil is undersized
- D. The condenser coil is dirty

Rationale: If the system has proper charge and airflow but high indoor humidity persists, the system is likely oversized — it short-cycles and does not run long enough to remove latent heat (moisture) from the air.

80. Per Cal/OSHA, a ladder must extend at least how many feet above the roofline when used for roof access?

- A. 6 feet
- B (correct). 3 feet**
- C. 1 foot
- D. 5 feet

Rationale: Cal/OSHA and OSHA require ladders used for access to an elevated surface to extend at least 3 feet above the landing point or roofline to provide safe handholds for mounting and dismounting.

81. The California Mechanical Code requires HVAC systems to be sized based on which load calculation method?

- A. The contractor's experience and judgment
- B. The same equipment size as the previous system
- C (correct). An approved heat loss/heat gain calculation per Manual J or equivalent**
- D. Rule-of-thumb sizing based on square footage

Rationale: California Mechanical Code Section 309.0 requires that HVAC equipment be sized based on an approved heat loss/heat gain calculation — Manual J or equivalent — not rule-of-thumb sizing.

82. During preventive maintenance on a split system, which of the following tasks should always be performed?

- A. Replace the compressor annually
- B (correct). Clean condenser coil, check pressures and temps, inspect electrical, clean filter, check condensate drain**
- C. Only check refrigerant pressures
- D. Only add refrigerant and replace filters

Rationale: PM on a split system should always include: checking and cleaning the condenser coil, checking refrigerant pressures and temperatures, inspecting electrical connections, cleaning or replacing filters, and checking condensate drain.

83. What reading on a combustion analyzer indicates incomplete combustion in a gas furnace?

- A. Complete and efficient combustion
- B. Normal combustion readings within spec
- C (correct). Incomplete combustion — insufficient air, cracked exchanger, or improper gas pressure**
- D. The furnace is operating at peak efficiency

Rationale: Elevated CO (carbon monoxide) in the flue gas indicates incomplete combustion, which can be caused by insufficient combustion air, a cracked heat exchanger, or improper gas pressure.

84. The grains of moisture per pound of dry air is a measure of:

- A. Wet-bulb temperature
- B (correct). Absolute moisture content (humidity ratio)**
- C. Dew point temperature
- D. Relative humidity

Rationale: Humidity ratio (grains of moisture per pound of dry air) measures the absolute moisture content of air. One pound of water contains 7,000 grains. This is distinct from relative humidity.

85. A system has low suction pressure and low head pressure. The most likely cause is:

- A (correct). Low refrigerant charge (undercharge)**
- B. Failed compressor valves
- C. Dirty condenser coil
- D. Overcharge of refrigerant

Rationale: Low suction and low head pressure together indicate low refrigerant charge (undercharge). The system does not have enough refrigerant to build adequate pressures on either side.

86. What is "latent heat" in the context of air conditioning?

- A (correct). Heat energy involved in condensing moisture from air without changing temperature**
- B. Heat conducted through building walls
- C. Heat associated with temperature change
- D. Radiant heat gain from sunlight

Rationale: Latent heat is the heat energy involved in a change of state — in HVAC, this refers to the energy required to condense moisture from the air (dehumidification) without changing the air temperature.

87. An air handler blower motor is drawing excessive amperage. The most likely cause is:

- A. Low voltage supply to the motor
- B. Incorrect belt tension on a belt-drive motor
- C (correct). Failing motor bearing, dirty blower wheel, or shorted motor winding**
- D. The motor is too small for the system

Rationale: Excessive amperage draw on a blower motor is most commonly caused by a failing motor bearing, a dirty blower wheel adding mechanical load, or a shorted motor winding.

88. The refrigerant line set for a split system should be insulated to prevent:

- A. Hold the line set in place
- B (correct). Prevent condensation and reduce heat gain**
- C. Protect the line from physical damage
- D. Prevent UV degradation of the copper tubing

Rationale: Suction line insulation prevents condensation (sweating) on the cold suction line, which can cause water damage, and reduces heat gain that would reduce system efficiency.

89. A dual-run capacitor failure on an air conditioning condensing unit most commonly causes:

- A (correct). Compressor or fan motor fails to start or draws high amperage**
- B. The TXV loses superheat control
- C. The condenser fan blows too much air
- D. Refrigerant migrates to the compressor

Rationale: A failed run capacitor causes the compressor or condenser fan motor (or both, if dual-run) to fail to start or operate with reduced torque, drawing high amperage and tripping the overload.

90. Electrical panels must remain accessible at all times. The minimum clearance in front of an electrical panel is:

- A. 24 inches
- B. 12 inches
- C (correct). 36 inches (3 feet)**
- D. No clearance required if door can close

Rationale: NEC 110.26 requires a minimum working space of 36 inches (3 feet) in front of electrical panels and equipment rated 0–150V to ground. This clearance must be maintained permanently.

91. A contractor on a job site discovers that an employee has symptoms of heat stroke. The correct immediate action is:

- A. Wait to see if symptoms improve before calling for help
- B. Have the victim walk to the emergency room
- C (correct). Move to cool area, apply ice packs to neck/armpits/groin, and call 911 immediately**
- D. Give the victim a cold drink and have them rest for 10 minutes

Rationale: Heat stroke is a life-threatening emergency. Move the victim to a cool area, apply ice packs to neck, armpits, and groin, and call 911 immediately. Do not leave the victim unattended.

92. When installing ductwork in an unconditioned attic, California Title 24 requires duct insulation of at least:

- A. R-30
- B. R-2
- C (correct). R-8**
- D. R-19

Rationale: California Title 24 Section 150.0(m) requires a minimum of R-8 duct insulation for supply and return ducts located in unconditioned spaces such as attics.

93. Which type of duct joint sealant is approved for use on HVAC duct systems per California Mechanical Code?

- A. Silicone caulk
- B. Spray foam insulation
- C (correct). UL 181A or UL 181B listed mastic or foil tape**
- D. Cloth duct tape

Rationale: California Mechanical Code and Title 24 require UL 181A or UL 181B listed mastic (duct sealant compound) or foil tape for sealing duct joints. Cloth duct tape is not listed and is not permitted.

94. CFM (cubic feet per minute) in duct design is primarily determined by:

- A. Fan motor horsepower
- B. Duct size alone
- C (correct). The heating or cooling load of the room being served**
- D. The number of occupants in the room

Rationale: Required airflow (CFM) at each supply outlet is determined by the heating or cooling load of the room being served. Typically approximately 400 CFM per ton of cooling capacity.

95. A takeoff sheet in HVAC estimating is used to:

- A (correct). List all materials and quantities required from reading the construction plans**
- B. List the HVAC equipment manufacturer warranties
- C. Document actual installed quantities after job completion
- D. Record customer complaints during the project

Rationale: A takeoff sheet is a document listing all materials, equipment, and quantities required for a job, derived from reading and measuring the construction plans before creating a cost estimate.

96. What is the design dry-bulb temperature used in load calculations?

- A (correct). The temperature exceeded only 1–2.5% of the time during peak season**
- B. The average annual high temperature
- C. The highest temperature ever recorded at the location
- D. The minimum outdoor temperature for winter design

Rationale: The design dry-bulb temperature is the outdoor temperature that HVAC systems are designed to maintain comfort at — typically the temperature exceeded only 1–2.5% of the time during summer or winter.

97. A heat pump reversing valve is energized in which mode on most residential systems?

- A. Both modes simultaneously
- B. Neither mode — it is always de-energized
- C. Heating mode
- D (correct). Cooling mode**

Rationale: On most residential heat pumps, the reversing valve is energized (solenoid activated) in cooling mode and de-energized in heating mode. This is the "O" designation on a thermostat.

98. A refrigerant system must be pressure tested before charging with refrigerant. What gas is used for leak testing?

- A. Carbon dioxide
- B (correct). Dry nitrogen**
- C. Oxygen
- D. Compressed air

Rationale: Dry nitrogen (never oxygen or air) is used for pressure testing refrigerant systems. Oxygen can cause explosions with oil, and air introduces moisture. Nitrogen is inert and dry.

99. The electrical disconnect for an HVAC unit must be located within sight of the equipment and within how many feet?

- A (correct). 50 feet**
- B. 10 feet
- C. 25 feet
- D. 100 feet

Rationale: The National Electrical Code (NEC) requires the disconnect to be within sight and within 50 feet of the equipment. "Within sight" means visible and not more than 50 feet distant.

100. A split system condenser fan motor is running but the compressor is not. The technician measures voltage at the compressor contactor. What should be checked next?

- A. Replace the contactor immediately
- B (correct). Check the run capacitor and internal overload protector**
- C. Replace the thermostat
- D. Add refrigerant to the system

Rationale: If voltage is present at the contactor but the compressor is not running, check the compressor start capacitor, run capacitor, and internal overload protector — the most common causes of compressor failure to start.

101. What is the purpose of a TXV (thermostatic expansion valve) in a refrigeration system?

- A (correct). Meter liquid refrigerant into the evaporator maintaining constant superheat**
- B. Remove moisture from the refrigerant circuit
- C. Measure suction pressure at the compressor inlet
- D. Compress refrigerant in the condenser

Rationale: A TXV meters the flow of liquid refrigerant into the evaporator coil, maintaining a constant superheat at the evaporator outlet regardless of load conditions, maximizing efficiency and protecting the compressor.

102. What type of respirator is required when working in spaces with oxygen-deficient atmospheres due to refrigerant accumulation?

- A (correct). A self-contained breathing apparatus (SCBA) or supplied-air respirator**
- B. A chemical cartridge respirator
- C. A standard N95 dust mask
- D. No respirator needed if under 30 minutes

Rationale: Standard dust masks and chemical cartridge respirators do not supply oxygen. A self-contained breathing apparatus (SCBA) or supplied-air respirator is required in oxygen-deficient atmospheres.

103. The enthalpy of air at a given condition represents:

- A. Only the temperature of the air
- B. The static pressure of the air stream
- C (correct). Total heat content per pound of dry air — sensible plus latent heat combined**
- D. The humidity ratio in grains per pound

Rationale: Enthalpy is the total heat content of air per pound of dry air, combining both sensible heat (temperature) and latent heat (moisture). It is used to calculate the total load on an HVAC system.

104. Refrigerant cylinders must never be heated with an open flame because:

- A. It is only prohibited for R-22 cylinders
- B. It would cool the cylinder too quickly
- C (correct). It can cause the relief valve to open or cylinder to rupture catastrophically**
- D. It would contaminate the refrigerant

Rationale: Heating a refrigerant cylinder with an open flame can cause the safety relief valve to open or the cylinder to rupture catastrophically. Warm water (below 120°F) is the only approved method to warm cylinders.

105. What is the function of a scroll compressor compared to a reciprocating compressor?

- A (correct). Quieter, more efficient, and more reliable than reciprocating compressors**
- B. Used only in commercial systems
- C. Requires higher refrigerant charge
- D. Less efficient than reciprocating compressors

Rationale: Scroll compressors use two interlocking spiral elements to compress refrigerant — they are quieter, more efficient, have fewer moving parts, and are more reliable than reciprocating (piston) compressors.

106. A new split system is charged by weight. After charging, the technician verifies correct charge by:

- A. Checking system pressures only
- B. Just by looking at the sight glass
- C. No verification needed after charging by weight

D (correct). Checking superheat and subcooling against manufacturer specifications

Rationale: Charging by weight is verified by checking superheat and subcooling readings against manufacturer specifications. If superheat and subcooling are within range, the charge by weight was accurate.

107. What symptom indicates that a TXV is stuck closed?

- A. Normal pressures with no superheat
- B. High suction pressure and low superheat
- C. High suction and high head pressure

D (correct). Very low suction pressure and extreme superheat

Rationale: A stuck-closed TXV starves the evaporator of refrigerant, causing very low suction pressure and extreme superheat — the compressor pulls suction down trying to draw refrigerant through the restricted metering device.

108. An air conditioning system has high suction pressure and high head pressure. Both pressures are elevated. The most likely cause is:

- A (correct). Overcharge — too much refrigerant**
- B. Low refrigerant charge
- C. Failed condenser fan motor
- D. Dirty evaporator coil

Rationale: High suction and high head pressure together indicates an overcharge condition — too much refrigerant in the system raises pressures on both the high and low sides.

109. Cal/OSHA requires that a safety data sheet (SDS) be available for which materials?

- A. Only for materials used outdoors
- B. Only for flammable materials
- C. Only for refrigerants above 50 lb cylinders

D (correct). All hazardous chemicals including refrigerants, solvents, fluxes, and cleaning chemicals

Rationale: Cal/OSHA Hazard Communication Standard (HCS) requires SDS for all hazardous chemicals and materials in the workplace, including refrigerants, solvents, fluxes, and cleaning chemicals.

110. Before entering a confined space such as a mechanical room or crawl space, a technician must:

- A (correct). Test for oxygen level, flammable gases, and toxic contaminants before entry**
- B. Enter and ventilate the space while working
- C. Have a coworker wait outside and enter immediately
- D. No special procedures required for crawl spaces

Rationale: OSHA and Cal/OSHA confined space procedures require atmospheric testing for oxygen content, flammable gases, and toxic contaminants before entry. A permit system is required for permit-required confined spaces.

111. A furnace heat exchanger must be inspected before startup to check for:

- A. Increased gas consumption only
- B. Reduced heating capacity only
- C. Furnace short-cycling

D (correct). Carbon monoxide mixing with supply air — a life-safety hazard

Rationale: A cracked heat exchanger allows combustion gases including carbon monoxide to mix with supply air, creating a life-safety hazard. Visual inspection and combustion analysis are required.

112. When installing a gas furnace, the supply air temperature rise must be within the manufacturer's specified range. Excessive temperature rise indicates:

- A. The furnace is oversized for the space
- B (correct). Insufficient airflow through the heat exchanger causing overheating**
- C. The gas pressure is too low
- D. The thermostat is set too high

Rationale: Excessive temperature rise (above the nameplate range) indicates insufficient airflow through the heat exchanger, which causes overheating, premature heat exchanger failure, and potential carbon monoxide production.

113. What gauge sheet metal is typically used for low-pressure residential duct systems?

- A. 30-gauge
- B. 20-gauge
- C. 14-gauge
- D (correct). 26-gauge galvanized steel**

Rationale: For low-pressure residential duct systems (up to 2" WG), 26-gauge galvanized steel is commonly used for small ducts and 24-gauge for larger ducts per SMACNA standards.

114. The electrical supply for a 240V split system air conditioner must be a dedicated circuit. The wire size is determined by:

- A (correct). 125% of the equipment's rated load current (MCA on nameplate)**
- B. The longest possible wire run
- C. The circuit breaker size only
- D. The contractor's preference

Rationale: NEC Article 440 requires the branch circuit conductor ampacity to be at least 125% of the equipment's rated load current (MCA — Minimum Circuit Ampacity) listed on the nameplate.

115. According to Cal/OSHA, roof work requires fall protection when working at heights of:

- A. 10 feet
- B. 4 feet
- C (correct). 7.5 feet**
- D. 6 feet

Rationale: Cal/OSHA General Industry Safety Orders require fall protection for employees working at heights of 7.5 feet or more above a lower level on roofs.