higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE

REFRIGERATION TRADE THEORY N3

(15040106)

5 August 2019 (X-Paper)
09:00–12:00

This question paper consists of 7 pages and 8 formula sheets.

DEPARTMENT OF HIGHER EDUCATION AND TRAINING
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE
REFRIGERATION TRADE THEORY N3
TIME: 3 HOURS
MARKS: 100

INSTRUCTIONS AND INFORMATION

1. Answer ALL the questions.
2. Read ALL the questions carefully.
3. Number the answers according to the numbering system used in this question paper
4. Write neatly and legibly.

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QUESTION 1

1.1 FIGURE 1.1 shows the simple mechanical refrigeration cycle. Study the sketch and state the condition of refrigerant as indicated by arrows in the sketch. Write only the correct answer next to number (1.1.1–1.1.5) in your ANSWER BOOK.

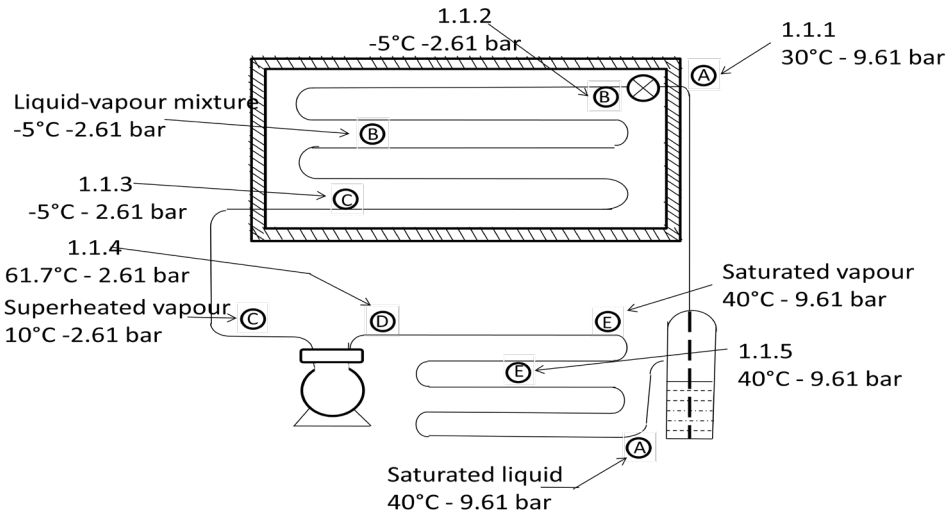


FIGURE 1.1 (5)

1.2 With reference to FIGURE 1.1 above describe the following terms:

1.2.1 Super-heated vapour

1.2.2 Saturated vapour

(2 × 3) (6)

1.3 The reading on an ordinary pressure gauge is 725 K Pa. What is the ordinary absolute pressure? (1)

1.4 The absolute pressure is 850 K Pa.

What is the ordinary pressure gauge reading? (1)

1.5 The temperature reading 330 K. What is the temperature in ℃ ? (1)

1.6 The temperature reading is -270 ℃. What is the temperature in Kelvin? (1)

1.7 The temperature reading is 88°f. What is the temperature reading in ℃ ? (1)

1.8 Name FOUR factors that have an effect on heat leakage. (4)

[20]

QUESTION 2

2.1 Name the FIVE main types of refrigerant controls. (5)

2.2 Make a neat labeled sketch of a thermostatic expansion valve. (7)

2.3 State THREE factors which determine efficiency of a compressor. (6)

2.4 Explain the purpose of refrigerant oil. (2)

[20]

QUESTION 3

3.1 Briefly describe the following control terms as used in the refrigeration systems:

3.1.1 Control point (2)

3.1.2 Sensor (2)

3.2 Draw a neat labeled sketch of a bulb type temperature sensing element and mechanism. Indicate the following parts/components on your sketch:

- Movable contact
- Stationary contact
- Spring
- Bulb
- Diaphragm adjustable screw
- Bellow

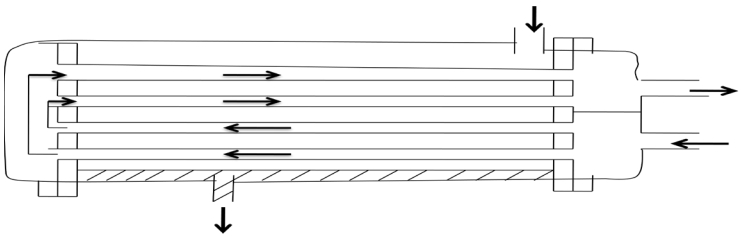
(6)

3.3 An eight-cylinder compressor rotating at 20 revolutions per second has a bore of 80 mm and a stroke of 88mm. This compressor was tested and was found to deliver refrigerant at a rate of 0.0225 m^3/s.

Calculate the volumetric efficiency of the compressor. (5)

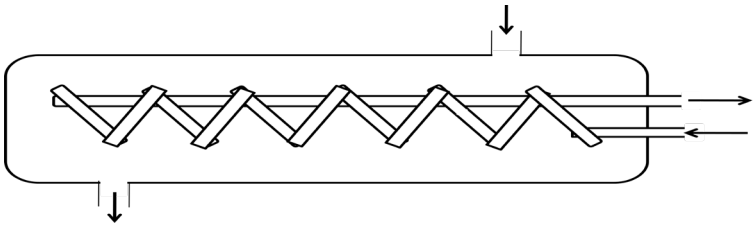
3.4 Identify the types of condensers below and write only the correct answer next to the number (3.3.1–3.3.2) in your ANSWER BOOK.

3.4 1



(1)

3.4.2



(1)

3.5 Briefly explain the operation of condenser numbered 3.4.2 (3)

[20]

QUESTION 4

4.1 Briefly describe the following evaporators

4.1.1 Defrosting (3)

4.1.2 Non-frosting (3)

4.2 Make a neat labeled sketch of a flooded evaporator. (6)

4.3 State FOUR properties of an effective valve assembly. (4 × 2) (8)

[20]

QUESTION 5

5.1 Define the term *coefficient of performance* (COP). (2)

5.2 The cooling capacity of a refrigeration plant is 30 kW. The coefficient of performance of the plant is 4,9. The refrigerant enthalpy gain in the evaporator is 145 kJ/kg.

Calculate the following:

5.2.1 The refrigerant mass flow rate

5.2.2 The work of compression

5.2.3 The power required by the compressor motor if the efficiency is 90%.

(3 × 2) (6)

5.3 FIGURE 5.3 below shows a P-H diagram for the refrigeration cycle. Study the diagram and answer the questions.

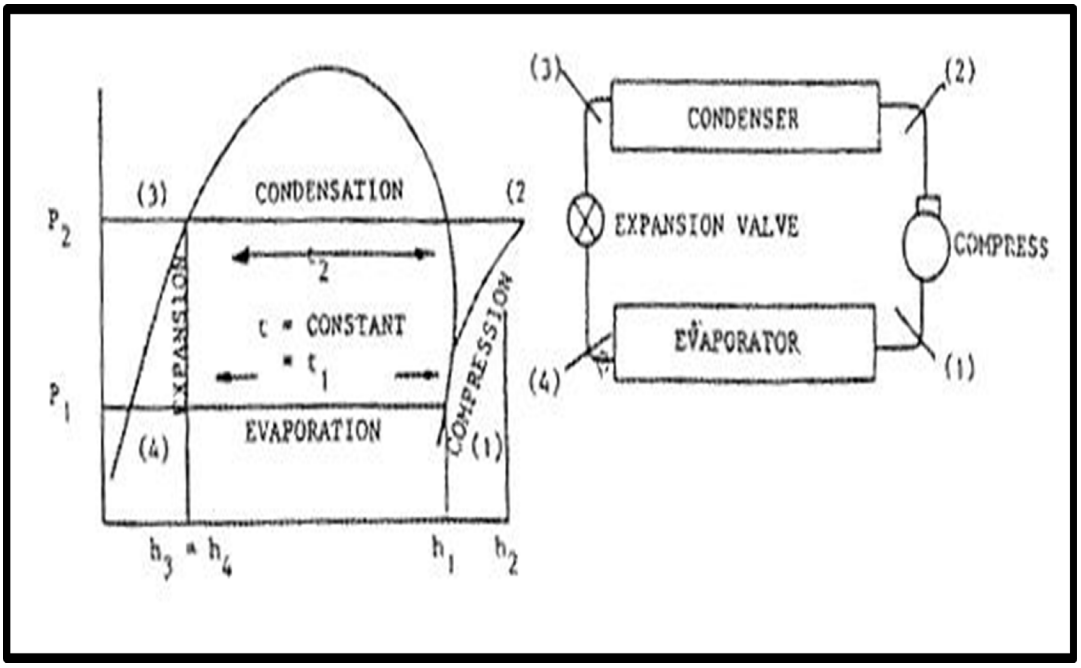


FIGURE 5.3

Describe the processes between the following numbers.

5.3.1 Process 1 to 2

5.3.2 Process 2 to 3

5.3.3 Process 3 to 4

5.3.4 Process 4 to 1

(4 × 2) (8)

5.4 Identify the types of control instrument below and write only the correct answer next to the number (5.4.1–5.4.2) in your ANSWER BOOK

5.4.1



(1)

5.4.2



(1)

5.5 State the purpose of the control instrument mentioned in QUESTION 5.4.2. (2)

[20]

TOTAL 100

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FORMULAE

REFRIGERATION TRADE THEORY N3

1. $Density = \frac{mass}{volume} \quad \therefore \rho = \frac{m}{v}\ kg/m^3$

   also $\rho = \frac{1}{v}\ kg/m^3 \quad (v = specific\ volume)$

2. $Specific\ volume\ (v) = \frac{1}{density} = \frac{1}{\rho}\ m^3/kg$

3. Greek symbols: $\eta = efficiency\ (neta)$
   $\rho = density\ (rho)$

4. $Mass\ flow\ rate: \left(\dot{m}\right)$

   $\dot{m} = \dot{V} \times \rho \quad Kg/S$

   $OR\ \dot{m} = \dot{V} \times \frac{1}{v} \quad \therefore \dot{m} = \frac{\dot{V}}{v}\ kg/s$

5. $(Quantity\ of\ heat\ (Q) for\ a\ change\ in\ temperature)$

   $Q = mC\Delta T\ kJ$

   $For\ a\ chnge\ of\ phase)$

   $Q = m.hfg$

   $(hfg = latent\ heat\ required\ )$

   $when\ the\ heat\ transfered\ reteis\ required\ the\ formula\ changes\ to:$
   $\dot{Q} = \dot{m}\ .\ hfg\ KJ/s\ or\ KW$

6. $Specific\ enthalphy\ (h)$

   To calculate the total energy transfer

   $\dot{Q} = \dot{Q}.\Delta h\ kJ/s\ or\ kW$

7. $Boyle's\ law:$

   $P_1V_1 = P_2V_2\ (at\ constan\ temperature)$

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8. $Charles's\ law$:

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

9. $ideal\ gas\ law$:

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

10. $The\ gas\ constant\ (R)$

$$R = \frac{Pv}{T}\ \ J/Kg.K$$

11. $Comperssor\ efficiency = \frac{Actual\ displacement(V)}{Thermal\ displacement(V\rho)}$

$$\eta = \frac{V}{V\rho} \times \frac{100}{1} = \%$$

12. $Theoretical\ displacement$:

$$V\rho = \frac{\pi \times D^2 \times L \times n \times N}{4}\ m^3/min$$

$$OR\ = \frac{\pi \times D^2 \times s \times N \times R}{4}\ m^3/min$$

$NOTE: (\pi = 3.142)$

13. $Evaporator\ capacity$:

(a) $The\ quantity\ of\ sensible\ heat\ transferred\ in\ watts$

$(evaporator\ sensible\ capacity)\ \left(\overset{\circ}{Q}\right)$

$$\overset{\circ}{Q}\ = U\ .A\ .\Delta t\ watts$$

(b) $Overall\ heat\ transfer\ coefficient\ ('U' - factor)$

$$U = \frac{1}{R}\ \ W/m^2.℃$$

(c) $Resistance\ of\ surface\ to\ heat\ flow\ (R)$

$$R = \frac{1}{U} = \frac{1}{h_0} + \frac{x}{k} + \left(\frac{Ao}{A_1} + \frac{1}{h_1}\right)\ \ m^2.℃/W$$

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(d) $Log\ mean\ temperature\ diferrence\ (LMTD)$

$$LMTD = \frac{(te-tr)-(t\ell-tr)}{\log n\left(\frac{te-tr}{t\ell-tr}\right)}\ ℃$$

14. $Condenser\ \ load$:

(a) $Total\ heat\ rejected\ of\ condenser\ in\ KW(THR)$

$$THR = \overset{\circ}{Qe} + \overset{\circ}{Q}\,i \quad \text{KW}$$

$$Also\ THR = refrigeration\ capacity \times heat\ rejected\ factor$$

(b) $Condenser\ capacity\ \left(\overset{\circ}{Q}\right)$

$$\overset{\circ}{Q} = U\,.A\,.\Delta t \quad kW$$

(c) $$LMTD = \frac{(tr-t\ell)-(tr-te)}{log\ n\left(\frac{tr-t\ell}{tr-te}\right)}$$

15. $The\ pressure\ enthalphy\ diagram$:

(a) $Refrigeration\ effect\ (Re)$

$$Re = h_1 - h_4 \quad kJ/kg$$

(b) $Heat\ of\ compression\ (WD)$

$$WD = h_2 - h_1 \quad kJ/kg$$

(c) $Heat\ rejection\ (THR)$

$$THR = h_2 - h_3 \quad kJ/kg$$

(d) $Coefficient\ of\ performance\ (COP)$:

$$COP = \frac{Re}{WD}\ (cooling)$$

$$COP = \frac{THR}{WD}\ \text{(heat pump)}$$

(e) $Refrigerant\ mass\ flow\ \left(\overset{\circ}{m}\right)$

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$$\dot{m} = \frac{Load}{Re}\ kg/s$$

(f) $Plant\ capacity\ = \dot{m} \times Re \quad kW$

(g) $Theoretical\ power = \dot{m} \times WD \quad kW$

(h) $Actual\ power = \frac{\dot{m} \times WD}{\eta} \quad kW$

(i) $Total\ heat\ rejected\ in\ kW\ \ (THR)$

$$THR\ in\ kW\ =\ \dot{m} \times THR\ in\ \ kJ/kg\ kW$$

(j) $The\ efficiency\ of\ a\ comressor$:

$$\% = \frac{Theoretical\ power\ input}{Actual\ power\ input} \times 100$$

OR

$$\% = \frac{h_2 - h_1}{h_{1_2} - h_1} \times 100$$

16. $Cooling\ \ load\ calculations$:

(a) $Basic\ heat\ transfer\ formula$

$$Q = U\ .A\ .\Delta T\ watts\ (J/S)$$

(b) $To\ calculate\ total\ resistance\ against\ heat\ flow$

$$Rt = \ \frac{1}{h_0} + \frac{d_1}{k_1} + \frac{d_2}{k_2} \cdots + \frac{1}{h_1}\ \ m^2.℃/W$$

(c) $heat\ transfer\ coefficient\ (U)$

$$U = \frac{1}{R_1}\ \ W/m^2.℃$$

(d) $Resistance\ against\ heat\ flow\ (R)$

$$\mathrm{R} = \frac{d}{k}\ \ m^2.℃/W$$

(e) $Total\ air\ change\ in\ cold\ room\ \left(\dot{V}\right)$

$$\dot{V} = \frac{V \times f}{86400} \quad m^3/s$$

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(f) *Total air change load* $\left(\overset{\circ}{Q}\right)$

(i) $\overset{\circ}{Q} = \overset{\circ}{V} \times \rho \times (h_2 - h_1) \times 1000$ *watts*

or when using the table for the number of air changes:

(ii) $\overset{\circ}{Q} = \frac{V \times f \times \rho \times \Delta h}{86.4}$ *watts*

The above formula is the combination of the 2 formulae given in (e)*and* $(f)(i)$

(g) *The product load*:

(i) *Sensible heat*:

$\overset{\circ}{Q} = \frac{\overset{\circ}{m} \cdot C \cdot \Delta t}{86.4}$ *watts*

(ii) *Latent heat*:

$\overset{\circ}{Q} = \frac{\overset{\circ}{m} \Delta h}{86.4}$ *watts*

(iii) *Heat respiration*:

$\overset{\circ}{Q} = \overset{\circ}{m} \cdot \Delta h$ *Watts*

(h) *Miscellaneous loads*:

(i) *Eqiupment load* $= \frac{\text{Equipment output} \times \text{hours of operation}}{24}$ *watts*

NB: Loadand output must be given in watts

(ii) *Lighting load* $= \frac{\text{Wattage of lighting} \times \text{hours of operation}}{24}$ *watts*

NB: When lighting is by means of fluorescent light, add 25% to the Lighting load.

.

(iii) *Occupancy load*:

$\overset{\circ}{Q} = \frac{\text{Heat equivalent per person} \times \text{number of persons} \times \text{hours}}{24}$ *watts*

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17. Ventilation and air conditioning:

(a) *Removal of latent heat*:

$$\overset{\circ}{Q} = \overset{\circ}{Q} \times \Delta g \times hfg \quad kW$$

$$\overset{\circ}{m} = \frac{\overset{\circ}{V}}{v} \; kg/s$$

$$\therefore \; \overset{\circ}{Q} = \frac{\overset{\circ}{V} \times \Delta g \times hfg}{v}$$

(b) *Room sensible heat factor* $(RSHF)$:

$$RSHF = \frac{RSH}{RSH+RLH} = \frac{RSH}{RTH}$$

(c) *Efficiency of an evaporative cooler*:

$$\eta = \frac{ta-tc}{ta-tb}$$

(d) *Cooling and dehumidification*:

$$\overset{\circ}{Q} = \overset{\circ}{m} \; [\Delta h - hfg(\Delta g)] \; kW$$

(e) $\overset{\circ}{V}$ *of the return air*

$$\overset{\circ}{Vra} = \overset{\circ}{Vra} - \overset{\circ}{V} fa \; m^3/s$$

(f) *Air temperature of mixture in the front of coil*

$$T = \frac{\left(\overset{\circ}{V} fa \times tdbfa \right) + \left(\overset{\circ}{V} ra \times tdbra \right)}{\overset{\circ}{Vsa}} \; ℃$$

(g) *Quantity of air*:

$$\overset{\circ}{V} = \frac{\overset{\circ}{Q}}{C \times \rho \times \Delta t} \; m^3/s$$

(h) *Amount of air forced through an opening by wind*:

$$\overset{\circ}{V} = E \times A \times v \quad m^3/s$$

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(i) $Volume\ flow\ due\ to\ temperature\ difference$:

$$\dot{V} = kA\sqrt{h(\Delta t)}\ \ m^3/s$$

(j) $Air\ changes\ per\ hour\ (f)$:

$$f = \frac{\dot{V} \times 3600}{V}\ \ changes/hour$$

(k) $Volume\ air\ low\ per\ m^2\ opening$:

$$\dot{V} = \frac{\dot{V}}{A}\ \ m^3/s/m^2$$

(l) $Free\ area\ of\ an\ opening\ (A)$:

$$A = total\ area \times\ \eta\ m^2$$

(m) $Louvre\ size\ for\ given\ air\ speed$:

$$= \frac{\dot{V} \times 100}{Number\ of\ inlets \times inlet\ speed \times \%\ A}\ m^2$$

18. $Fans$:

(a) $Fan\ total\ pressure\ (Pt)$

$$Pt = Ps + Pv\ \ kPa$$

(b) $Theoretical\ power\ of\ the\ fan$:

$$= \dot{V} \times Pt\ \ kW$$

(c) True power of the fan:

$$= \frac{\dot{V} \times Pt}{\eta}\ kW$$

(d) $Air\ power\ (Ap)$

$$Ap = \frac{\dot{Q} \times Pt}{N}\ \ kW$$

(e) $Brake\ power\ (Bp)$

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$$Bp = \frac{\overset{\circ}{Q} \times pt}{\eta\, t} = \frac{\overset{\circ}{Q} \times ps}{\eta\, t}$$

$$\therefore Bp = \frac{Pt}{\eta\, t} = \frac{Ps}{\eta\, s} \quad (for\ the\ same\ volume)$$

19. Fan laws:

$$(a)\ \frac{VOL_1}{VOL_2} = \frac{N_1}{N_2} \times \frac{(DIA_1)^3}{(DIA_2)^3}$$

$$(b)\ \frac{P_1}{P_2} = \frac{(N_1)^2}{(N_2)^2} \times \frac{(DIA_1)^2}{(DIA_2)^2} \times \frac{\rho_1}{\rho_2}$$

$$(c)\ \frac{kW_1}{kW_2} = \frac{(N_1)^3}{(N_2)^3} \times \frac{(DIA_1)^5}{(DIA_2)^5} \times \frac{\rho_1}{\rho_2}$$

$$\frac{DIA_1}{DIA_2} = \frac{N_1}{N_2}$$

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