higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE

REFRIGERATION TRADE THEORY N3

(11041583)

30 November 2023 (X-paper)
09:00–12:00

Nonprogrammable calculators may be used.

This question paper consists of 4 pages and a formula sheet of 6 pages.

175Q1E2330

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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. Use only a blue or black pen.
5. Write neatly and legibly.

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QUESTION 1

1.1 Name the THREE general classifications of fans. (3)

1.2 Briefly describe the following terms as used in refrigeration:

1.2.1 Superheated vapour

1.2.2 Saturated vapour

1.2.3 Specific heat capacity

1.2.4 Latent heat

1.2.5 Set point

1.2.6 Enthalpy

(6 × 2) (12)

1.3 Name the FIVE main types of refrigeration control. (5)
[20]

QUESTION 2

2.1 Explain the term *miscellaneous heat loads.* (2)

2.2 Name FOUR sources of miscellaneous heat loads. (4)

2.3 Explain the use of the following refrigeration components:

2.3.1 Valve

2.3.2 Strainer

2.3.3 Pipe union

(3 × 2) (6)

2.4 Explain the operation of the pressure regulating valve as used in absorption units. (5)

2.5 Name THREE types of expansion valves used in refrigeration systems. (3)
[20]

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QUESTION 3

3.1 State FOUR methods of capacity control on compressors. (4 × 2) (8)

3.2 State THREE advantages of hermetic sealed compressors. (3)

3.3 An eight-cylinder compressor rotating at 12 r/s has a bore of 70 mm and a stroke length of 80 mm. It delivers refrigerant vapour at a rate of 0,0225 m^3/s under these specifications.

Calculate the volumetric efficiency of the compressor. (5)

3.4 Copy the following table in the ANSWER BOOK and complete it by filling in THREE main differences between the compression system and the absorption system.

COMPRESSION SYSTEM	ABSORPTION SYSTEM
(3 × 1)	(3 × 1)

(6)

3.5 Name ONE method of compressor lubrication. (1)

3.6 What is meant by the phrase *to crack a service valve*? (2)

[25]

QUESTION 4

4.1 Name TWO types of water-cooled condensers. (2)

4.2 State FOUR factors contributing to heat leakage. (4)

4.3 What is the purpose of an oil separator in a refrigeration system? (2)

4.4 Explain the term *liquid accumulator* and state its function as well as where it should be installed in the system. (3)

4.5 Name FOUR different rooms as used in a locker plant. (4)

[15]

QUESTION 5

5.1 State 12 steps in sequence to be followed to determine the efficiency of an open-type refrigeration compressor. (12)

5.2 State FIVE important points that must be taken into account when installing refrigerant piping. (5)

5.3 State why a filter drier is installed in a refrigeration system and state the line in which it should be fitted. (3)

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

   $\dot{m} = \dot{V} \times \rho \ \ kg/s$

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

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

   $Q = mC\Delta T\ \ kJ$
   $For\ a\ change\ of\ phase)$

   $Q = m.hfg$
   $(hfg\ = latent\ heat\ required)$
   $when\ the\ rate\ of\ the\ heat\ transferred\ is\ required\ the\ formula\ changes\ to:$
   $\dot{Q} = \dot{m}\ .\ hfg\ kJ/s\ of\ kW$

6. $Specific\ enthalphy\ (h)$

   To calculate the total energy transfer
   $\dot{Q} = \dot{Q}.\Delta h\ \ kJ/s$ ***or*** kW

7. $Boyle's\ law$:

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

8. $Charles'\ law$:
   $\frac{V_1}{T_1} = \frac{V_2}{T_2}$

9. $Ideal\ gas\ law$:
   $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$

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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. $Theoretical\ displacement$:

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

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

$NOTE: (\pi = 3{,}142)$

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

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

(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) $Total\ heat\ rejected\ of\ condenser\ in\ kW\ (THR)$

$$THR = \overset{\circ}{Q}e\ +\ \overset{\circ}{Q}\ i\ \ \text{kW}$$

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

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

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

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

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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):

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

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

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

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

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

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

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

(i) *Total heat rejected in kW* (THR)

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

(j) *The efficiency of a compressor*:

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

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*

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

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(c) *Heat transfer coefficient* (U)

$$U = \frac{1}{R_1} \quad W/m^2.℃$$

(d) *Resistance against heat flow* (R)

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

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

$$\overset{\circ}{V} = \frac{V \times f}{86\,400} \quad m^3/s$$

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

(i) $\overset{\circ}{Q} = \overset{\circ}{V} \times \rho \times (h_2 - h_1) \times 1\,000 \ watts$

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

(ii) $\overset{\circ}{Q} = \frac{V \times f \times \rho \times \Delta h}{86{,}4} \quad watts$

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

(g) *The product load*:

(i) *Sensible heat*:

$$\overset{\circ}{Q} = \frac{\overset{\circ}{m} \ . \ C \ . \Delta t}{86{,}4} \quad watts$$

(ii) *Latent heat*:

$$\overset{\circ}{Q} = \frac{\overset{\circ}{m} \ \Delta h}{86{,}4} \quad watts$$

(iii) *Heat respiration*:

$$\overset{\circ}{Q} = \overset{\circ}{m} \ . \ \Delta \ h \ watts$$

(h) *Miscellaneous loads*:

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

NB: *Load and output must be given in watts*

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

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

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(iii) *Occupancy load*:

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

17. *Ventilation and air conditioning*:

(a) *Removal of latent heat*:

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

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

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

(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*:

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

(i) *Volume flow due to temperature difference*:

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

(j) *Air changes per hour* (f):

$$f = \frac{\overset{\circ}{V} \times 3\,600}{V} \ changes/hour$$

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

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

(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) $Brake\ power\ (Bp)$

$$Bp = \frac{\dot{Q} \times pt}{\eta\ t} = \frac{\dot{Q} \times ps}{\eta\ t}$$

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

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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