Name : **Date:**

HVAC Learning.com

Exercise Booklet

Print this exercise booklet before studying the lesson on line. It will enable you to write your answers to the HVAC learning exercises. You will thus be able to switch between reading or listening to the file on-line and writing in the booklet.

CALCULATING WATER AND AIR FLOW RATES PART-1

English lesson:
https://hvac-learning.com/base-physics/physics-level-1/calculating-water-and-air-flow-rates-part-1/

French lesson:
https://formation.xpair.com/cours/calcul-pratique-debits-eau-air-partie-1.htm

For each exercise, you will write your answer, then you will study its correction on-line before going to the next exercise.
If you cannot do an exercise, you will be able to study its correction directly, but ***force yourself to write your answer*** *as often as possible.*

Note that between 2 exercises, you will find it necessary to study the course. As a warning, in the booklet, you will sometimes find the following indication:

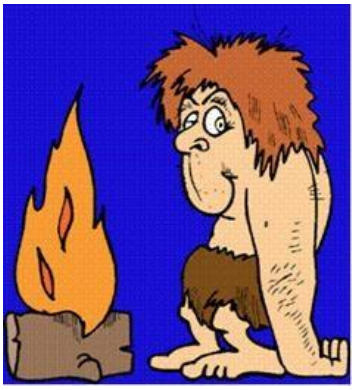
- *" **Study the course on-line before doing the next exercise**" or*
- *" **Study the course on-line before going to the next paragraph**"*

Only study the paragraphs or the exercises which have an equal or a lower level than the one your training requires.
NVQ Level = Vocational Certificate
A Level = High school Diploma
HND Level = Associate's Degree
MSC Level = Engineering Schools

Then, when you have completed a file, you will be able to assess your level on-line through a Multiple Choice Questionnaire in which you will only answer the questions related to the themes you have studied.
So now off you go and work well!
Good luck!
The Authors.

N°1 – Volumetric heat of water and air in Wh and kWh training – A level

Study the course on-line before treating the next exercise.



C_{water} = 4.18 [kJ/kg.K]   (3.96 Btu/kg.K)

C_{air} = 1 [kJ/kg.K] (0.95 Btu/kg.K)

Cv_{water} = 1.16 [kWh/m³.K] (3,958 Btu/kg.K)

Cv_{air} = 0.34 [Wh/m³.K]   (1.16 Btu/kg.K)

Question 1

How can we explain that the specific heat of water is vastly superior to that of air?
1.16 [kWh/m³.K] (3,958 Btu/kg.K) for water and only 0.34 [Wh/m³K] (1.16 Btu/kg.K) for air.

Question 2

Knowing that ρ_{water} = 1000 [kg/m³] and Cm_{water} = 4.18 [kJ/kg.K] (3,958 Btu/kg.K), demonstrate that $Cv_{water} \approx$ 1.16 [kWh/m³.K].

Question 3

Knowing that with air at 20 [°C] (68 °F) we can accept that:
ρ_{air} = 1.2 [kg/m^3] and C_{air} = 1 [kJ/kg.K]. Demonstrate that $C_{air} \approx 0.34$ [Wh/m^3.K].

N°2 – Calculation of heat required to heat water training – HND level

Study the course on-line before treating the next exercise.

Q = **M** × **4.18** × **ΔT** (for water)
With:
– Q: Quantity of heat in [kJ]
– M: Treated mass in [kg]
– 4.18: Specific heat of water in [kJ/kg.K]
– ΔT: range of temperature loss or gain in [°C](or [K])

Q = **V** × **1.16** × **ΔT** (for water)
With:
– Q: Quantity of heat in [kWh]
– V: Treated volume in [m^3]
– 1.16: Volumetric heat of water in [kWh/m^3.K]
– ΔT: range of temperature loss or gain in [°C] (or [K])

Question 1

Working with volumetric heat, determine in [kWh], the quantity of heat required to heat up 3 [m^3] (792 US gal) of water by 15 [°C] (15 [K])?

Question 2

Working with volumetric heat, determine in [kWh], the quantity of heat required to heat up 500 [l] (132 US gal) of water from 10 to 50 [°C] (from 50 °F to 122 °F)?

Question 3

What quantity of heat is required in [kWh] to cool 300 [l] (79 US gal) of water from 50 [°C] to 15 [°C] (from 122°F to 59°F)?

Question 4

Knowing that 1 [kWh] corresponds to 3,600 [kJ], what quantity of heat, expressed in [kJ], is required to be removed from 3.5 [m^3] of water for it to cool down from 12 [°C] to 7 [°C] (from 53.6°F to 44.6°F)?

N°3 – Relation between flow rate, speed, pipe gauge training – A level

Study the course on-line before treating the next exercise.

For a given gauge, the higher the speed, the greater will be the flow rate.

q_v = v x **S**
With:
– *q_v : volume flow in [m^3/s]*
– *v : fluid velocity in [m/s]*
– *S : cross section in [m^2]*

Question 1

In a circular duct of D 710 (diameter 710 [mm]), air flow is measured at 4 [m/s].
What is the air flow in [m^3/s] and in [m^3/h]?

Question 2

In a pipeline of D 250 (diameter 250 [mm]), water flow speed is measured at 2 [m/s].
What is the water flow in [m^3/s] and in [m^3/h]?

Question 3

What in [m/s] is an air flow speed of 4,500 [m^3/h], in a rectangular duct of 500 [mm] × 600 [mm]?

Question 4

What in [m/s] is an air flow speed of 4,000 [m^3/h], in a pipe of D 500?

Question 5

What in [m/s] is a water flow velocity of 350 [m^3/h], in a pipeline of D 250?

Question 6

We want to pass 15,000 [m^3/h] of air at 6 [m/s] through a rectangular duct. What in [m^2] will be the cross section area of the duct? Knowing that the height will be 700 [mm], what in [m] will be the width of the duct?

Question 7

We want to pass 2,800 [m^3/h] of air at 4 [m/s] through a circular duct.
What in [m^2] will be the cross section surface area of the duct?
What in [m] will be the diameter of the duct?

Question 8

We want to pass 9,500 [m^3/h] of air at 6 [m/s] through a circular duct.
What in [m^2] will be the cross section surface area of the duct?
What in [m] will be the diameter of the duct?

N°4 – Relation between flow rate, heat power and temperature difference of air training – A level

Study the course on-line before treating the next exercise.

P = **q_v** × **0.34** × **ΔT**
With:
– P in [W]
– q_v in *[m^3/h]*
– 0.34: Volumetric heat of air in [Wh/m^3.K]
– ΔT: Temperature difference gained or lost by air (in [K])

Question 1

Explain very simply why the introduction of air flow in [m^3/h] leads to power in [W] whereas with water the introduction of a flow in [m^3/h] leads to[kW].

Air handling unit (AHU)


AHU heating coil

Question 2

What is the power in [W] and in [kW] of a unit which heats by 35 [°C] (35 [K]) an air flow of 750 [m^3/h] (26,490 ft^3/hour)?

Question 3

What is the power of a unit which heats 1,200 [m^3/h] (42,380 ft^3/hour) of air from 15 [°C] to 32 [°C] (from 59°F to 89.6°F)?

Question 4

What is the power of a heat coil which warm up 3,500 [m^3/h] (123,600 ft^3/hour) of air from -7 [°C] to +26 [°C] (from 19.4°F to 78.8°F)?

Question 5

What calorific power was supplied by 180 [m^3/h] (6,357 ft^3/hour) of air blown at 33 [°C] (91.4°F) into a room at 20 [°C] (68°F)?

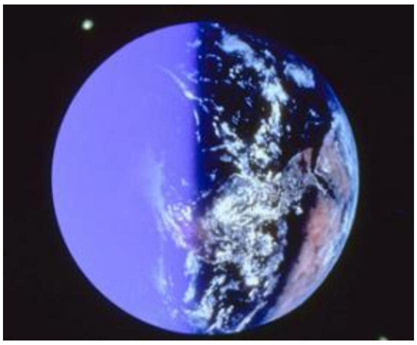
Question 6

What cooling power was supplied by 230 [m^3/h] (8,122 ft^3/hour) of air blown at 17 [°C] (62.6°F) into a room at 25 [°C] (77°F)?

Study the course on-line before treating the next paragraphe.

N°5 – International system of units training – HND level

Study the course on-line before treating the next exercise.



- **For water:**

Practical Formula	International Formula
$P = q_v \times 1.16 \times \Delta T$ *With:* *- P in [kW]* *- q_v in [m³/h]* *- 1.16: Volumetric heat in [kWh / m³ K]* *- ΔT: Range of temperature loss or gain* (in [K])	**$P = q_m \times 4.18 \times \Delta T$** *With:* *- P in [kW]* *- q_m in [kg/s]* *- 4.18: Volumetric heat in [kJ / kg K]* *- ΔT: Range of temperature loss or gain* (in [K])

Question 1

To how many [kg/s], does a flow of 12 [m^3/h] (52.8 US gmp) of water correspond?

Question 2

To how many [kg/s], does a flow of 80 [l/h] (0.352 US gmp) of water correspond?

Question 3

What heating capacity in [kW] is necessary to heat by 45 [°C] (45 [K]), a water flow of 12 [m^3/h] (52.83 US gmp)?
Use the two available formulas.

Question 4

What heating capacity in [W] is necessary to heat from 15 [°C] to 50 [°C] (from 59°F to 122°F), a water flow of 110 [l/h] (0.484 US gmp)? *Use the two available formulas.*

- **For air:**

Practical Formula *Applied to air at 20 [°C]*	**International Formula** *Applied whatever the air temperature*
$\mathbf{P = q_v \times 0.34 \times \Delta T}$ *With:* *- P in [W]* *- q_v in [m³/h]* *- 0.34: Volumetric heat in [Wh / m³ K]* *- ΔT: Range of temperature loss or gain*	$\mathbf{P = q_m \times 1 \times \Delta T = q_m \times \Delta T}$ *With:* *- P in [kW]* *- q_m in [kg/s]* *- 1: Specific heat of air in [kJ / kg K]* *- ΔT: Range of temperature loss or gain*

Question 5

Knowing that the density of air at 20 [°C] (68°F) is 1.2 [kg/m³], to how many [kg/s], does an air flow of 15,000 [m³/h] (529,700 ft³/hour) at 20 [°C] (68°F) correspond?

Question 6

Knowing that the density of air at 20 [°C] (68°F) is 1.2 [kg/m³], to how many [kg/s], does an air flow of 8,000 [m³/h] (282,500 ft³/hour)) at 20 [°C] (68°F) correspond?

Question 7

What heating capacity is necessary to heat by 35 [°C] (35 [K]), an air flow of 15,000 [m³/h] (529,700 ft³/hour) (brought to 20 [°C] or 68°F)? *Use the two available formulas.*

Question 8

What heating capacity is required to heat from – 5 [°C] to +27 [°C] (from 23°F to 80.6°F) an air flow of 2,500 [m^3/h] (88,290 ft^3/hour) (brought to 20 [°C] or 68°F)? *Use the two available formulas.*

N°6 – Which formula to use? HND level

This chapter to be studied only at HND level & higher.

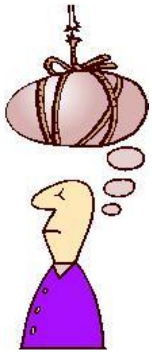
Study the course on-line before treating the next exercise.

Practical Formula	International Formula
Water: **P** = $\mathbf{q_v}$ × **1.16** × **ΔT** *With:* - *P in [kW]* - *q_v in [m³/h]* - *1.16: Volumetric heat in [kWh / m³ K]* - *ΔT: Range of temperature loss or gain* (in [K])	**Water:** **P** = $\mathbf{q_m}$ × **4.18** × **ΔT** *With:* - *P in [kW]* - *q_v in [kg/s]* - *C: Specific heat = 4.18 [kJ / kg K]* - *ΔT: Range of temperature loss or gain* (in [K])
Air: **P** = $\mathbf{q_v}$ × **0.34** × **ΔT** *With:* - *P in [W]* - *q_v in [m³/h]* - *0.34:* **Volumetric** *heat in [Wh / m³ K]* - *ΔT: Range of temperature loss or gain (in [K])*	**Air:** **P = $\mathbf{q_m}$** × **ΔT** *With:* - *P in [kW]* - *q_v in [kg/s]* - *ΔT: Range of temperature loss or gain (in [K])*

N°7 – Alternative practical formula used in air conditioning training – HND level

This § will only be studied at HND level & higher. At A level standard training we'll go directly to the final test.

Study the course on-line before treating the next exercise.



When you study design dossiers of air conditioning systems, for the calculations of heating capacity on air, a new formula will be used leading of course to the same results as the preceding ones (rounded up or down).

$$P = \frac{q_v}{3000} \times \Delta T$$

With P in [kW], q_v in [m^3/h], ΔT in [K]

Question 1

The power of a unit heating 5,000 [m^3/h] (176,600 ft^3/hour)of air from 8 [°C] to 32 [°C] (from 46.4°F to 89.6°F) is:

$$P = \frac{5000}{3000} \times (32\text{-}8) = 40[kW]$$

Check this result using the previously studied formulas ($P = q_v \times 0.34 \times \Delta T$ and $P = q_m \times c \times \Delta T$).

English lesson:
https://hvac-learning.com/base-physics/physics-level-1/calculating-water-and-air-flow-rates-part-1/

French lesson:
https://formation.xpair.com/cours/calcul-pratique-debits-eau-air-partie-1.htm

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