Surname **Name** **Student's code:**

Section 1. QUIZ

1. The sonar level sensors always provide the contemporary measurement of the temperature
   a. true □ false □
2. In a "air-to-open" valve the air operates on the actuator in order to move away the closure member from the seat
   a. true □ false □
3. Closed-end liquid column manometers ("U" tube manometers) containing mercury are used for measuring pressure in a vacuum
   a. true □ false □
4. When specifying a thermal mass flowmeter, it is not necessary to know the specific gas types to be measured.
   a. true □ false □

Section 2. MULTIPLE CHOICE QUESTIONS

1. Butterfly valves are:

□ rotary motion control valves
□ linear stem motion control valves
□ ball control valves
□ motorized control valves

2. The working principle of a pressure transducer can be:
   NOTE: check only the wrong answer!

□ piezoelectric
□ radio
□ inductive
□ electric resistance

3. Which one is NOT a dimensionless sensor property?
   □ accuracy at the full scale
   □ accuracy at the measured value
   □ rangeability
   □ sensitivity

4. With reference to a control valve, which of the following statements is incorrect?

a. ☐ the normal flow is $p_{vc}>p_v$
b. ☐ the semicritical flow is $p_{vc}\leq p_v$ e $p_2>p_v$
c. ☐ it is in vena contracta $p_{vc}\geq p_1$
d. ☐ the flow limit is $p_{vc}<p_v$ and $p_2\leq p_v$

Section 3: SENSORS AND MEASURING INSTRUMENTS PROCESS

3.1 The Resistance Temperature Detector (RTD)

a. Describe in 3 rows its working principle

3.2 Inductive Differential Pressure transducer

a. Describe in 3 rows its working principle

3.3. Sensors' properties

a) Draw a suitable diagram just to show the difference between **accuracy** and **precision** for a process variable that is measured during time

b) Static characteristic: Provide the definition in 3 rows max

c) Static characteristic: Provide one example of it

3.4. Throttle flow meters

a) Obtain the flow rate equation in the ideal case

b) Calculate the flow rate measured for water with the following data: P1=90 kPa, P2=60 kPa, d1=55 mm, d2=25 mm

c) Extend the flow rate equation to non-ideal cases

d) Extend the flow rate equation to the case of non-constant density

3.5. Positive-displacement flow meter

a. Please provide an explanation how it works (in 3 text lines)

3.6 The rotary vane flow meter

a. Provide a schematic drawing of how it works

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Section 4: VALVES

4.1 Valve technology

Draw a simple sketch, explain purpose and features of each one of the following valves.

a. Ball cock

b. Butterfly control valve

c. Angle valve

d. Three-way valve

NOTE: A well organized and short text will be assessed more than a long and confused one!

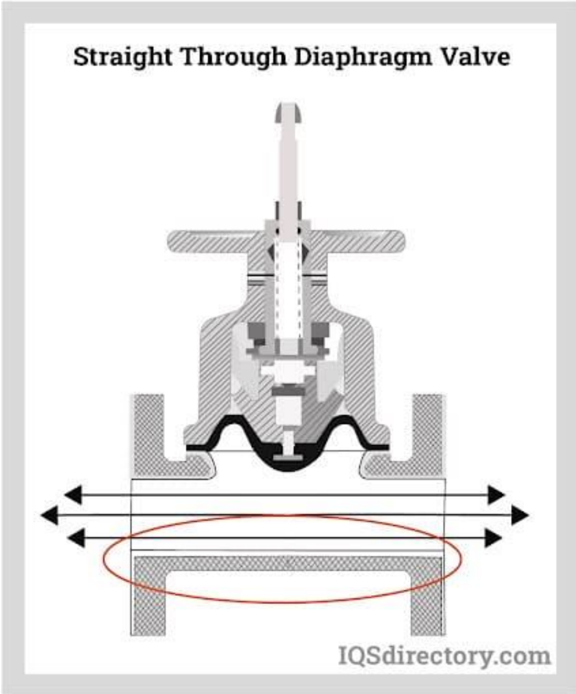
4.2 Sizing Problem

The sizing is required for a valve under the following conditions:

liquid: ethyl alcohol
density: ρ=806 kg/m^3
nominal diameter of the line: DN = 2 in
nominal flow: $\dot{m}$ = 12 kg/s
pressure upstream of the valve: P_1= 15÷20 bar
pressure downstream of the valve: P_2= 14 bar
vapor pressure: 0.02 bar
Coefficient of the ratio of the critical pressure for liquids: F_F = 0.956

1. Calculate the most suitable **flow coefficient** C_v for the above conditions

The following **diafragm valve "Xomox Straight-Thru screwed end"** with a scheme like the following one:



is available from the manufacturer, with:

- a unique intrinsic characteristic
- a **recovery coefficient** F_L=0.7
- the following **manufacturer's Table**

DN (in)	**½"**	**1"**	**1 ½"**	**2"**
h (%)	**C_v** [gpm psi$^{-0.5}$]			
10	1.4	3	9.4	14.8
20	2.8	6	18.7	30
30	4.3	9.3	28.9	46
40	5.8	12.5	39	62
50	7.0	15	47	74
60	8.2	17.5	55	86
70	9.0	19.3	60	95
80	9.9	21.3	66	105
90	10.9	23.3	73	114
100	11.7	25.0	78	123

2. **Size the valve** for the above-mentioned problem, choosing the one with the most suitable DN.

3. Draw the **intrinsic characteristic** of the chosen valve

4. Calculate the three points of the **flow characteristic**, report them on a graph and determine if the valve operates in **normal flow**.

Subsequently, you are required to insert the chosen valve in a circuit, assuming ΔP_n equal to the original value (P_1 - P_2) and considering the **"user" pressure drop**: $\Delta P_u = \Delta P_n/2$

5. How much is the authority V ?

6. Calculate the value of $\dot{V}_n$

7. How much is the flow rate $\dot{V}_1(h)$ that will pass through the valve for $h_1 = 0.2$?

8. How much is the actual pressure drop ΔP_{v1} across the valve for $h_1 = 0.2$?

9. How much will the relative stroke h_2 be if a flow rate $\dot{V}_2(h) = 42.5$ gal(US)/min will pass through the valve inserted in the **circuit**?

Then, you are asked:

11. Under the nominal conditions and with the same $\Delta P_n = (P_1 - P_2)$ used in the original sizing, is the selected valve able to pass a flow rate $\dot{V}_v = 450$ gpm of acetic acid, with density $\rho = 1049$ kg/m^3 ?

Again, you have to face the **verification problem** for the previously sized valve:

12. Still in nominal conditions and with the $\Delta P_n = (P_1 - P_2)$ used in the original sizing, what is the maximum flow rate of acetic acid that the selected valve is able to pass?