الجامعة الوطنية
National University
Science & Technology للعلوم والتكنولوجيا
كلية عمان البحرية الدولية
International Maritime College Oman

Final Exam
PT-TICHEM: INDUSTRIAL CHEMISTRY
Fall 2025

Points of attention:

- For each question, the maximum earned points are specified in the question.
- Write clearly! Answers that are not readable are not marked and don't earn marks!
- All answers should be written in English using **blue or black pens** only.
- Use the pencil only for diagrams and graphs.
- Show all the calculation steps in the given space.
- When finished, submit the question paper, together with the answer scripts and the signed cover page to the invigilator.
- Any cheating/copying may result in an instant failing of the examination.

Exam Duration:	2 hrs. 30 min.
Instructor's Name:	Dr. G. CHANDRASEKAR
Exam Date:	06/01/2026
Program:	PE

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Student Information			
Name:		ID:	
Signature:			

Invigilator			
Initials:		☐ Student ID checked	
Time received:			

Question 1 : Multiple choice questions (MCQ) [5 marks]

Answer all the questions below: (5 x 1 = 5) marks

(i) Animal fat is used to prepare

(a) Detergents (b) Vegetable oil

(c) Soap (d) Polyethylene

(ii) The material utilized in the Solvay process and recovered from it is

(a) Na_2CO_3 (b) NH_3

(c) $(NH_4)_2CO_3$ (d) $NaHCO_3$

(iii) The pore size of the membrane used in reverse osmosis is

(a) 1.0 - 10.0 nm (b) 0.1-1.0 nm

(c) 0.15 -2.0 nm (d) > 0.1 nm

(iv) The cleansing action of soap is due to the formation of:

(a) Esters (b) Micelles

(c) Scum (d) Acids

(v) The lime-soda process works on the principle of:

(a) Ion exchange (b) Precipitation

(c) Adsorption (d) Distillation

Question 2: Fill in the blank with correct answers [5 marks]

Answer all the questions below: (5 x 1 = 5 marks)

(i) The number of moles of Na_2CO_3 in 250,000 tons is _____.

(ii) Sulphonic acid group is present in _____ ion exchange resin.

(iii) In the reverse osmosis processes, the _____ pressure should be_____than the osmotic pressure.

(iv) The residual hardness in the treated water from zeolite process is _____ ppm.

(v) The grease or dirt part will be attracted towards _____part of the detergents.

Question 3: **[7 marks]**

Hardness is caused by certain ions, and it is a major problem in industries mainly in scale formation and corrosion in boilers. The ions need to be calculated for the hardness and treated to soften the water for the industrial uses.

1. Provide the chemical equation for the removal of temporary hardness of Mg and Ca from the water. (2 marks)
2. A water sample from a Cement industry in Seoul, South Korea had the following data: $Ca(HCO_3)_2$ = 47.8 mg/L, $MgSO_4$ = 52 mg/L, $MgCO_3$ = 64 ppm, $CaCl_2$ =24.0 mg/L, KOH = 1 ppm and $Al(OH)_3$ = 2 ppm. Calculate the temporary, permanent and total hardness of the water sample. (5 marks)

Question 4: **[7 marks]**

The soda lime process is extensively used in municipal water treatment plants to supply portable water to civil society.

1. Sketch the experimental set-up of hot soda-lime process. (2 marks)
2. Explain the hot soda-lime process for softening of water. (3 marks)
3. Mention any four advantages of hot-soda lime process. (2 marks)

Question 5: **[7 marks]**

(i) The manager of the laundry unit in snow-white detergents company demonstrated the usage of detergent to remove the grease on the worker's uniform. If you were the manager, how would you explain the cleansing action of detergent on the dirty clothes with neat sketch. (4 marks)

(ii) Mention the three types of detergents based on molecular charges with their chemical structures. (3 marks)

Question 6: **[9 marks]**

(i) Limestone is used as raw materials for the sodium carbonate production by Solvay process. Explain the industrial process of Na_2CO_3 production with neat diagram and necessary chemical equations. (5 marks)

(ii) A company in South Australia, called Penrice Soda Products Pty Ltd, produces 750 000 tons per year of soda ash (sodium carbonate). How many tons of calcium carbonate are needed to produce this? (4 marks)

Take the overall equation as, $CaCO_{3(s)} + 2NaCl_{(aq)} \rightarrow Na_2CO_{3(aq)} + CaCl_{2(aq)}$

IUPAC Periodic Table of the Elements

Key:

atomic number **Symbol** name abridged standard atomic weight

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 **H** hydrogen 1.0080 ± 0.0002																	2 **He** helium 4.0026 ± 0.0001
3 **Li** lithium 6.94 ± 0.06	4 **Be** beryllium 9.0122 ± 0.0001											5 **B** boron 10.81 ± 0.02	6 **C** carbon 12.011 ± 0.002	7 **N** nitrogen 14.007 ± 0.001	8 **O** oxygen 15.999 ± 0.001	9 **F** fluorine 18.998 ± 0.001	10 **Ne** neon 20.180 ± 0.001
11 **Na** sodium 22.990 ± 0.001	12 **Mg** magnesium 24.305 ± 0.002											13 **Al** aluminium 26.982 ± 0.001	14 **Si** silicon 28.085 ± 0.001	15 **P** phosphorus 30.974 ± 0.001	16 **S** sulfur 32.06 ± 0.02	17 **Cl** chlorine 35.45 ± 0.01	18 **Ar** argon 39.95 ± 0.16
19 **K** potassium 39.098 ± 0.001	20 **Ca** calcium 40.078 ± 0.004	21 **Sc** scandium 44.956 ± 0.001	22 **Ti** titanium 47.867 ± 0.001	23 **V** vanadium 50.942 ± 0.001	24 **Cr** chromium 51.996 ± 0.001	25 **Mn** manganese 54.938 ± 0.001	26 **Fe** iron 55.845 ± 0.002	27 **Co** cobalt 58.933 ± 0.001	28 **Ni** nickel 58.693 ± 0.001	29 **Cu** copper 63.546 ± 0.003	30 **Zn** zinc 65.38 ± 0.02	31 **Ga** gallium 69.723 ± 0.001	32 **Ge** germanium 72.630 ± 0.008	33 **As** arsenic 74.922 ± 0.001	34 **Se** selenium 78.971 ± 0.008	35 **Br** bromine 79.904 ± 0.003	36 **Kr** krypton 83.798 ± 0.002
37 **Rb** rubidium 85.468 ± 0.001	38 **Sr** strontium 87.62 ± 0.01	39 **Y** yttrium 88.906 ± 0.001	40 **Zr** zirconium 91.224 ± 0.002	41 **Nb** niobium 92.906 ± 0.001	42 **Mo** molybdenum 95.95 ± 0.01	43 **Tc** technetium [97]	44 **Ru** ruthenium 101.07 ± 0.02	45 **Rh** rhodium 102.91 ± 0.01	46 **Pd** palladium 106.42 ± 0.01	47 **Ag** silver 107.87 ± 0.01	48 **Cd** cadmium 112.41 ± 0.01	49 **In** indium 114.82 ± 0.01	50 **Sn** tin 118.71 ± 0.01	51 **Sb** antimony 121.76 ± 0.01	52 **Te** tellurium 127.60 ± 0.03	53 **I** iodine 126.90 ± 0.01	54 **Xe** xenon 131.29 ± 0.01
55 **Cs** caesium 132.91 ± 0.01	56 **Ba** barium 137.33 ± 0.01	57-71 lanthanoids	72 **Hf** hafnium 178.49 ± 0.01	73 **Ta** tantalum 180.95 ± 0.01	74 **W** tungsten 183.84 ± 0.01	75 **Re** rhenium 186.21 ± 0.01	76 **Os** osmium 190.23 ± 0.03	77 **Ir** iridium 192.22 ± 0.01	78 **Pt** platinum 195.08 ± 0.02	79 **Au** gold 196.97 ± 0.01	80 **Hg** mercury 200.59 ± 0.01	81 **Tl** thallium 204.38 ± 0.01	82 **Pb** lead 207.2 ± 1.1	83 **Bi** bismuth 208.98 ± 0.01	84 **Po** polonium [209]	85 **At** astatine [210]	86 **Rn** radon [222]
87 **Fr** francium [223]	88 **Ra** radium [226]	89-103 actinoids	104 **Rf** rutherfordium [267]	105 **Db** dubnium [268]	106 **Sg** seaborgium [269]	107 **Bh** bohrium [270]	108 **Hs** hassium [269]	109 **Mt** meitnerium [277]	110 **Ds** darmstadtium [281]	111 **Rg** roentgenium [282]	112 **Cn** copernicium [285]	113 **Nh** nihonium [286]	114 **Fl** flerovium [290]	115 **Mc** moscovium [290]	116 **Lv** livermorium [293]	117 **Ts** tennessine [294]	118 **Og** oganesson [294]

57 **La** lanthanum 138.91 ± 0.01	58 **Ce** cerium 140.12 ± 0.01	59 **Pr** praseodymium 140.91 ± 0.01	60 **Nd** neodymium 144.24 ± 0.01	61 **Pm** promethium [145]	62 **Sm** samarium 150.36 ± 0.02	63 **Eu** europium 151.96 ± 0.01	64 **Gd** gadolinium 157.25 ± 0.03	65 **Tb** terbium 158.93 ± 0.01	66 **Dy** dysprosium 162.50 ± 0.01	67 **Ho** holmium 164.93 ± 0.01	68 **Er** erbium 167.26 ± 0.01	69 **Tm** thulium 168.93 ± 0.01	70 **Yb** ytterbium 173.05 ± 0.02	71 **Lu** lutetium 174.97 ± 0.01
89 **Ac** actinium [227]	90 **Th** thorium 232.04 ± 0.01	91 **Pa** protactinium 231.04 ± 0.01	92 **U** uranium 238.03 ± 0.01	93 **Np** neptunium [237]	94 **Pu** plutonium [244]	95 **Am** americium [243]	96 **Cm** curium [247]	97 **Bk** berkelium [247]	98 **Cf** californium [251]	99 **Es** einsteinium [252]	100 **Fm** fermium [257]	101 **Md** mendelevium [258]	102 **No** nobelium [259]	103 **Lr** lawrencium [262]

MLO and Bloom's Level of Complexity

Q #	MLO Addressed	Complexity Level	Mark	Remark
1	**1,2,3**	Knowledge, Apply, Analyze	**5**	3 of 4 problems are required
2	**1, 2, 3**	Knowledge, Apply, Analyze	**5**	
3	**1,5**	Design/Create & Evaluate	**7**	
4	**2, 3**	Apply & Analyze	**7**	
5	**1, 3, 4**	Understand, Apply & Evaluate	**7**	
6	**1, 3, 4**	Analyse, Apply & Evaluate	**9**	