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

ACADEMIC YEAR 2023 - 2024

Program	Year	Semester	Paper
PE	2	2	Main

MODULE NAME:	**Industrial Chemistry**		
MODULE CODE:	**TICHEM**	**EXAM DATE:**	**20/05/2024**
INSTRUCTOR's NAME:	**Dr. Muna Al-Hinai**	**DURATION:**	**2.5 hrs.**

Questions to be answered on:	**Allowed tools:**	**Number of pages**
✓ Space provided on the question paper	Pen, Pencil & Calculator	(Incl. cover page)**: 10**

Points of attention:

- For each question, the maximum earned points are mentioned between brackets at the end of each question.
- Write very clearly! Answers that are not readable are not marked and don't get points!
- Make sure your answers are written to the point.
- All answers should be written **in English.**
- Write all the answers in **blue or black pen only.**
- Use the **pencil** only for **diagrams & 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.

FINAL MARKS

	40
	10

STUDENT NAME:

STUDENT ID:

Number of answer scripts:……..…….

Invigilator:……..……..

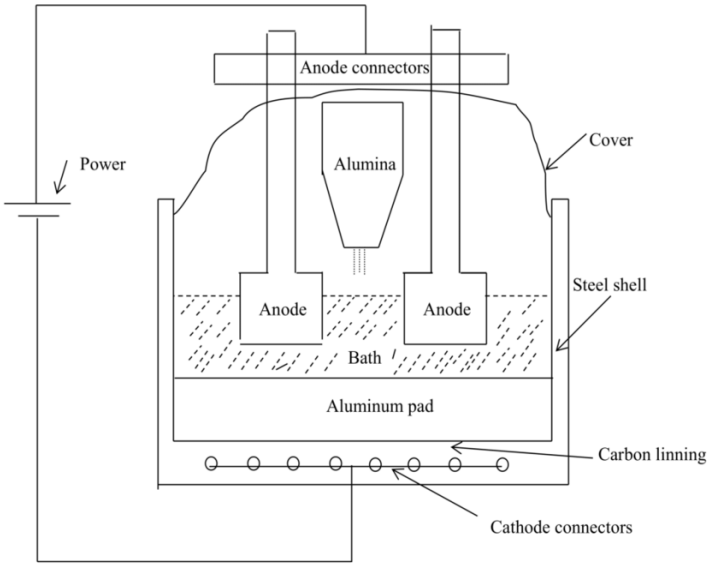
Student's signature: ……

Time of receipt:……..…..

Instructions: Answer all questions in exam paper.

Question 1 (MLO 1, 2, 3, 4, Understand, apply, analyze, evaluate) (10 Marks)

Hall- Heroult Process is a major process for smelting aluminum. Alumina (aluminum oxide, Al2O3) is extracted from aluminum ores mainly bauxite and dissolved at ~ 950 °C in molten cryolite (sodium hexafuolroaluminate Na3AlF6). Elemental aluminum is produced by electrolysis f the molten cryolite by passing voltage of 5 V at 100- 300 kA. Analyze the Hall- Heroult rocess diagram below to answer the questions.



(Obaidate, 2018)

a. State the balanced reaction at the cathode. **(2 Marks)**

b. State the balanced reaction at the anode. **(2 Marks)**

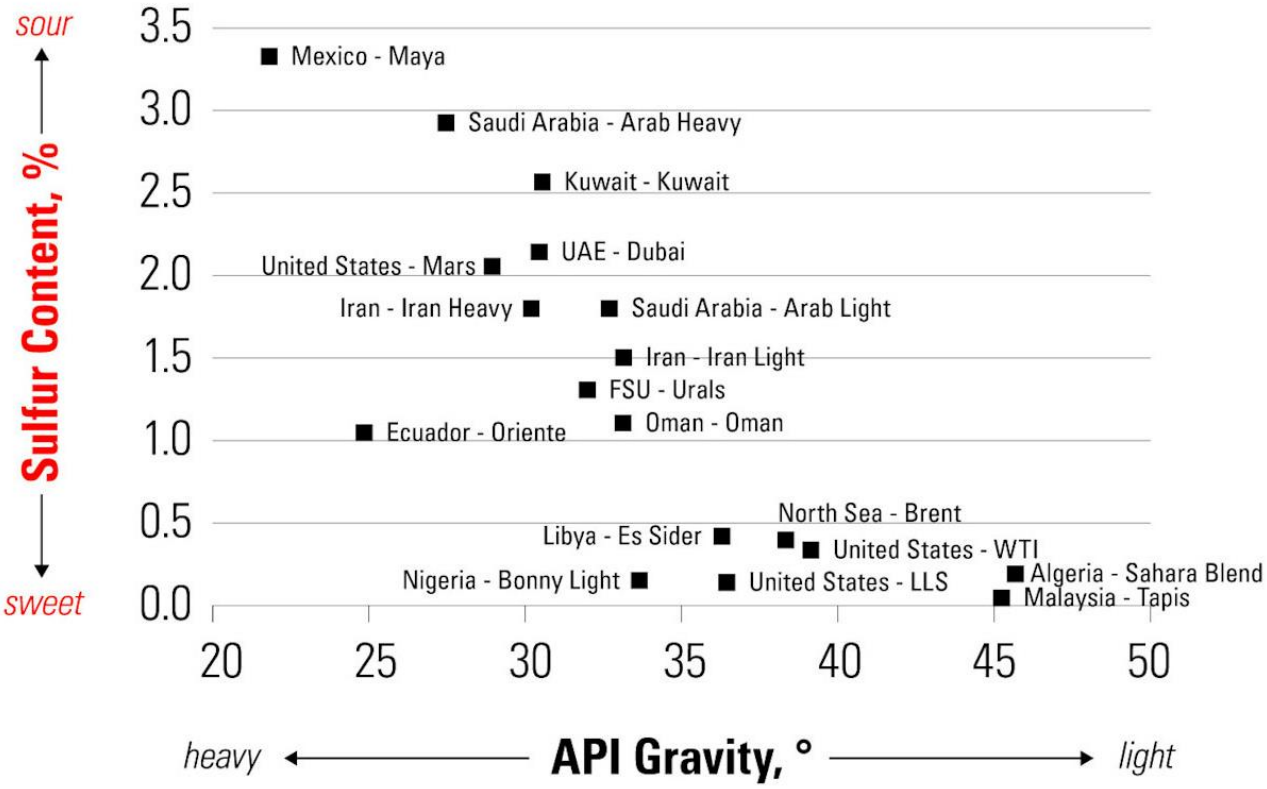
c. Write the overall reaction and determine the cell potential. **(3 Marks)**

d. The electrolyte in Hall- Heroult process is Na_3AlF_6 and AlF_3 is added as additive. Explain the purpose of adding fluorinated salts to the process. **(1 Mark)**

e. CO_2 and HF are produced during the operation of Hall- Heroult process. Explain how aluminum manufacturers ca reduce the environmental pollution from the process. **(2 Marks)**

Question 2 (MLO 2, 3, 4, apply, analyze, evaluate) (14 Marks)

American peroleum institute gravity (API gravity) and sulfur content are two scale for peroleum qualification. The chart below compares the API gravity and sulfur content of different types of oil. Analyze the chart and answer the following questions.



Source: U.S. Energy Information Administration, based on Energy Intelligence Group—International Crude Oil Market Handbook.

United States-Mars is an offshore drilling site in the Gulf of Mexico. WTI = West Texas Intermediate; LLS = Louisiana Light Sweet; FSU = Former Soviet Union; UAE = United Arab Emirates.

(Andrews, 2023)

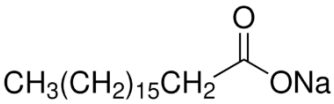
a. Determine the specific gravity of Saudi Arabia- Arab Heavy oil and Saudi Arabia- Arab Light oil and which is lighter? **(4 Marks)**

b. Compare the quality of these oils: Saudi Arabia- Arab Heavy, Ecuador- Oriente, UAE- Dubai, Oman- Oman, and North Sea- Brent and justify your answer from sulfur content and API gravity value. **(6 Marks)**

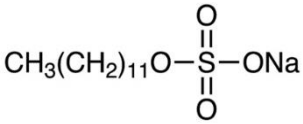
c. Arrange the expected price of oils in part b from the lowest price to the highest and justify your answer. **(4 Marks)**

Question 3 (MLO 1, 3, 4, Understand, analyze, evaluate) (8 Marks)

Soap and detergent are substances that are used in cleansing agents. When soap and detergents dissolved in water, possess the ability to remove dirt from surfaces such as the human skin, textiles, and other solids. The cleansing action of both soaps and detergents results from their ability to lower the surface tension of water, to emulsify oil or grease and to hold them in a suspension in water. Structures below illustrate two substances that are used in cleansing agents. Analyze the two structures and answer the following questions.



Sodium stearate (Merck, 2024)



Sodium dodecyl sulfate (TIC, 2024)

a. Complete the table below to compare the two strudctures. **(4 Marks)**

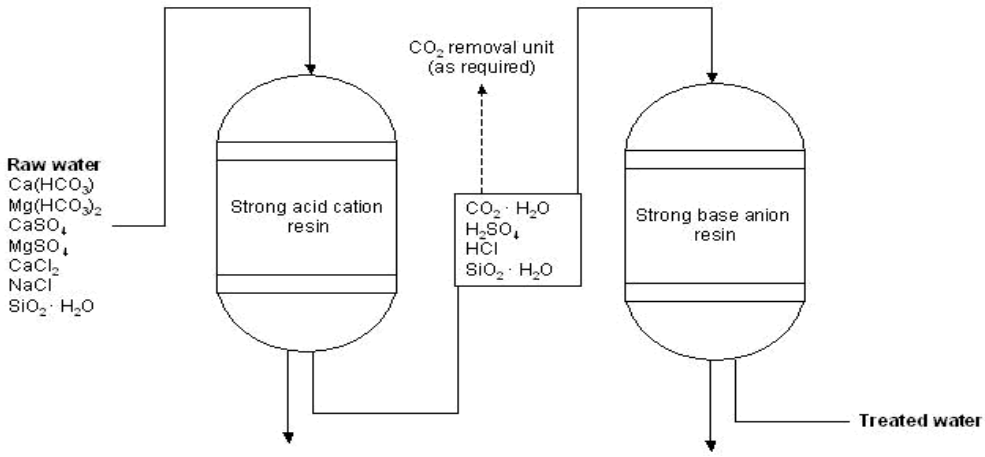
	Sodium stearate	Sodium dodecyl sulfate
Classification (Soap or detergent)		
Fat source		
Head functional group		
Leathering in hard water		

b. Explain this statement: “soaps and dteregents are surface active agents”. **(2 Marks)**

c. Predict the chemical reaction for the production of sodium stearate. **(2 Marks)**

Question 4 (MLO 3, 4, analyze, evaluate) (8 Marks)

Deionization is the removal of electrically charged substance from water. Deionization is achieved in different methods including ion exchange resins and fixed bed deionization. The diagram below shows deionization process, and the table illustrates some resins that are used in the exchangers. Analyze the diagram and the table to answer the questions.



(Lenntech, 2024)

A	R-CH-(NH_2)-CH_3
B	R-C=(NH)-CH_3
C	R-PO_3H_2
D	R-CH_2-OH

a. State the **three** type of ions that are removed in cationic exchangers. **(1.5 Marks)**

b. State **two resins** from the table that are used in cationic exchangers. **(1 Mark)**

c. State the **three** type of ions that are removed in anionic exchangers. **(1.5 Marks)**

d. State **two resins** from the table that are used in anionic exchangers. **(1 Marks)**

e. Compare the hardness removal action in ion- exchangers and fixed- bed deionizers. **(3 Marks)**

References

Andrews, K., (2023), Types of Crude Oil: Heavy vs Light, Sweet vs Sour, and TAN count, KIMRAY, Retrieved online on 14th April 2024 from: https://kimray.com/training/types-crude-oil-heavy-vs-light-sweet-vs-sour-and-tan-count

Obaidat, M., Al-Ghandoor, A., Phelan, P., Villalobos, J., & Alkhalidi, A. (2018). Energy and exergy analyses of different aluminum reduction technologies. *Sustainability (Switzerland)*, Vol. 0(4), Article 1216. https://doi.org/10.3390/su10041216

Periodic table of Elements, (2021) *Printable*, Retrieved online on 24th April 2022, from: https://www.printablee.com/post_periodic-table-of-elements-printable_400652/

Standard Reduction Potential, (2013), Retrieved online on 24th April 2022, from: https://ch302.cm.utexas.edu/echem/echem-cells/selector.php?name=std-red-potentials

Sodium dodecyl sulfate, (2024), TCI, Retrieved online on 30th April 2024 from: https://www.tcichemicals.com/IN/en/p/S0588

Sodium stearate, (2024), Merck, Retrieved online on 30th April 2024 from: https://www.sigmaaldrich.cn/CN/en/product/sigma/s3381

Deionized/ Demineralized Water, (2024), Lenntech, Retrieved online on 30th April 2024 from: https://www.lenntech.com/applications/process/demineralised/deionised-demineralised-water.htm

Periodic Table of the Elements

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 H Hydrogen 1.008																	2 He Helium 4.003
3 Li Lithium 6.941	4 Be Beryllium 9.012											5 B Boron 10.811	6 C Carbon 12.011	7 N Nitrogen 14.007	8 O Oxygen 15.999	9 F Fluorine 18.998	10 Ne Neon 20.180
11 Na Sodium 22.990	12 Mg Magnesium 24.305											13 Al Aluminum 26.982	14 Si Silicon 28.086	15 P Phosphorus 30.974	16 S Sulfur 32.066	17 Cl Chlorine 35.453	18 Ar Argon 39.948
19 K Potassium 39.098	20 Ca Calcium 40.078	21 Sc Scandium 44.956	22 Ti Titanium 47.88	23 V Vanadium 50.942	24 Cr Chromium 51.996	25 Mn Manganese 54.938	26 Fe Iron 55.933	27 Co Cobalt 58.933	28 Ni Nickel 58.693	29 Cu Copper 63.546	30 Zn Zinc 65.39	31 Ga Gallium 69.732	32 Ge Germanium 72.61	33 As Arsenic 74.922	34 Se Selenium 78.09	35 Br Bromine 79.904	36 Kr Krypton 84.80
37 Rb Rubidium 84.468	38 Sr Strontium 87.62	39 Y Yttrium 88.906	40 Zr Zirconium 91.224	41 Nb Niobium 92.906	42 Mo Molibdenum 95.94	43 Tc Technetium 98.907	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.906	46 Pd Palladium 106.42	47 Ag Silver 107.868	48 Cd Cadmium 112.411	49 In Indium 114.818	50 Sn Tin 118.71	51 Sb Antimony 121.760	52 Te Tellurium 127.6	53 I Iodine 126.904	54 Xe Xenon 131.29
55 Cs Cesium 132.905	56 Ba Barium 137.327	57-71 Lanthanides	72 Hf Hafnium 178.49	73 Ta Tantalum 180.948	74 W Tungsten 183.85	75 Re Rhenium 186.207	76 Os Osmium 190.23	77 Ir Iridium 192.22	78 Pt Platinum 195.08	79 Au Gold 196.967	80 Hg Mercury 200.59	81 Tl Thallium 204.383	82 Pb Lead 207.2	83 Bi Bismuth 208.980	84 Po Polonium [208.982]	85 At Astatine 209.987	86 Rn Radon 222.018
87 Fr Francium 223.020	88 Ra Radium 226.025	89-103 Actinides	104 Rf Rutherfordium [261]	105 Db Dubnium [262]	106 Sg Seaborgium [266]	107 Bh Bohrium [264]	108 Hs Hassium [269]	109 Mt Meitnerium [268]	110 Ds Darmstadtium [269]	111 Rg Roentgenium [272]	112 Cn Copernicium [277]	113 Uut Ununtrium unknown	114 Fl Flerovium [289]	115 Uup Ununpentium unknown	116 Lv Livermorium [298]	117 Uus Ununseptium unknown	118 Uuo Ununoctium unknown

57 La Lanthanum 138.906	58 Ce Cerium 140.115	59 Pr Praseodymium 140.908	60 Nd Neodymium 144.24	61 Pm Promethium 144.913	62 Sm Samarium 150.36	63 Eu Europium 151.966	64 Gd Gadolinium 157.25	65 Tb Terbium 158.925	66 Dy Dysprosium 162.50	67 Ho Holmium 164.930	68 Er Erbium 167.26	69 Tm Thulium 168.934	70 Yb Ytterbium 173.04	71 Lu Lutetium 174.967
89 Ac Actinium 227.028	90 Th Thorium 232.038	91 Pa Protactinium 231.036	92 U Uranium 238.029	93 Np Neptunium 237.048	94 Pu Plutonium 244.064	95 Am Americium 243.061	96 Cm Curium 247.070	97 Bk Berkelium 247.070	98 Cf Californium 251.080	99 Es Einsteinium [254]	100 Fm Fermium 257.095	101 Md Mendelevium 258.1	102 No Nobelium 259.101	103 Lr Lawrencium [262]

Standard Potentials at 25°C

Half Reaction	Potential
$F_2 + 2e^- \rightarrow 2F^-$	+2.87 V
$O_3 + 2H^+ + 2e^- \rightarrow O_2 + H_2O$	+2.07 V
$S_2O_8^{2-} + 2e^- \rightarrow 2SO_4^{2-}$	+2.05 V
$PbO_2 + 4H^+ + SO_4^{2-} + 2e^- \rightarrow PbSO_4 + 2H_2O$	+1.69 V
$Au^+ + e^- \rightarrow Au$	+1.69 V
$Pb^{4+} + 2e^- \rightarrow Pb^{2+}$	+1.67 V
$2\,HClO + 2H^+ + 2e^- \rightarrow Cl_2 + 2H_2O$	+1.63 V
$Ce^{4+} + e^- \rightarrow Ce^{3+}$	+1.61 V
$MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$	+1.51 V
$Au^{3+} + 3e^- \rightarrow Au$	+1.40 V
$Cl_2 + 2e^- \rightarrow 2Cl^-$	+1.36 V
$Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow 2Cr^{3+} + 7H_2O$	+1.33 V
$O_2 + 4H^+ + 4e^- \rightarrow 2H_2O$	+1.23 V
$MnO_2 + 4H^+ + 2e^- \rightarrow Mn^{2+} + 2H_2O$	+1.21 V
$Pt^{2+} + 2e^- \rightarrow Pt$	+1.20 V
$Br_2 + 2e^- \rightarrow 2Br^-$	+1.09 V
$2Hg^{2+} + 2e^- \rightarrow Hg_2^{2+}$	+0.92 V
$ClO^- + H_2O + 2e^- \rightarrow Cl^- + 2OH^-$	+0.89 V
$Ag^+ + e^- \rightarrow Ag$	+0.80 V
$Hg_2^{2+} + 2e^- \rightarrow 2Hg$	+0.79 V
$Fe^{3+} + e^- \rightarrow Fe^{2+}$	+0.77 V
$MnO_4^- + 2H_2O + 3e^- \rightarrow MnO_2 + 4OH^-$	+0.60 V
$I_2 + 2e^- \rightarrow 2I^-$	+0.54 V
$O_2 + 2H_2O + 4e^- \rightarrow 4OH^-$	+0.40 V
$Cu^{2+} + 2e^- \rightarrow Cu$	+0.34 V
$Hg_2Cl_2 + 2e^- \rightarrow 2Hg + 2Cl^-$	+0.27 V
$AgCl + e^- \rightarrow Ag + Cl^-$	+0.22 V
$NO_3^- + H_2O + 2e^- \rightarrow NO_2^- + 2OH^-$	+0.01 V
$2H^+ + 2e^- \rightarrow H_2$	**0.000 V**

Half Reaction	Potential
$2H^+ + 2e^- \rightarrow H_2$	**0.000 V**
$Fe^{3+} + 3e^- \rightarrow Fe$	−0.04 V
$Pb^{2+} + 2e^- \rightarrow Pb$	−0.13 V
$Sn^{2+} + 2e^- \rightarrow Sn$	−0.14 V
$Ni^{2+} + 2e^- \rightarrow Ni$	−0.23 V
$V^{3+} + e^- \rightarrow V^{2+}$	−0.26 V
$Co^{2+} + 2e^- \rightarrow Co$	−0.28 V
$In^{3+} + 3e^- \rightarrow In$	−0.34 V
$PbSO_4 + 2e^- \rightarrow Pb + SO_4^{2-}$	−0.36 V
$Cd^{2+} + 2e^- \rightarrow Cd$	−0.40 V
$Cr^{3+} + e^- \rightarrow Cr^{2+}$	−0.41 V
$Fe^{2+} + 2e^- \rightarrow Fe$	−0.44 V
$Zn^{2+} + 2e^- \rightarrow Zn$	−0.76 V
$2H_2O + 2e^- \rightarrow H_2 + 2OH^-$	−0.83 V
$Cr^{2+} + 2e^- \rightarrow Cr$	−0.91 V
$Mn^{2+} + 2e^- \rightarrow Mn$	−1.18 V
$V^{2+} + 2e^- \rightarrow V$	−1.19 V
$ZnS + 2e^- \rightarrow Zn + S^{2-}$	−1.44 V
$Al^{3+} + 3e^- \rightarrow Al$	−1.66 V
$Mg^{2+} + 2e^- \rightarrow Mg$	−2.36 V
$Na^+ + e^- \rightarrow Na$	−2.71 V
$K^+ + e^- \rightarrow K$	−2.92 V
$Li^+ + e^- \rightarrow Li$	−3.05 V

Note: all ions are aqueous (aq), many neutral species are solids (s), although some are liquids (l), gases (g), and even aqueous (aq). Use other sources for details on state. They were purposely left off here to save space and keep a cleaner looking table.