SCH4U Unit 3 - Practice Questions B

SECTION 1: Short Answer

11. Identify each of the following as an endothermic or exothermic reaction:

(i) hydrogen undergoes nuclear fusion in the Sun to produce helium atoms _____

(ii) water changes from a liquid to a solid_____

(iii) you shake a medical pack and it gets colder_____

(iv) the **wax** in a candle melts from the wick burning _____ *[A, 4]*

Use your understanding of Hess's Law to solve the following questions:

12. Consider the following reaction mechanism

A proposed three-step mechanism is:

Step 1: $2C + O_2 \rightarrow 2\,CO$

Step 2: ?

Step 3: $2H_2 + O_2 \rightarrow 2H_2O$

Overall: $3\,C + 2H_2 + 3\,O2 \rightarrow 2CO + CO_2 + 2H_2O$

(a) Write the missing equation for step 2. *[A, 2]*

(b) Identify the reaction intermediate(s). *[A, 1]*

13. Consider the following reaction mechanism

Step 1: $C_2H_6 + 3.5\ O_2 \rightarrow 2\ CO_2 + 3\ H_2O$

Step 2: $C_2H_4 + 3O_2 \rightarrow 2CO_2 + 2\ H_20$

Step 3: $2H_2 + O_2 \rightarrow 2H_2O$

Write the overall reaction: *[A, 3]*

SECTION 2: Calculations

14. A water tank contains 2.0×10^9 g of water. When the water is warmed by solar energy, its temperature increases from 18°C to 23°C. How much heat does the water absorb? Express your answer to 3 significant digits. *[T/I, 4]*

15. Solutions of hydrogen iodide and sodium hydroxide where mixed in a calorimeter by Mrs. Chang. She mixes 80.0 mL of 0.60 mol/L HI (aq) with 80.0 mL of 0.60 mol/L NaOH (aq), both maintained at an initial temperature of 22.7 degrees Celsius. The highest temperature attained by the mixture is 25.3 degrees Celsius. Assume the solution has the same density as water. The specific heat of water is 4.186 J/g°C. Answer the following questions to 3 significant digits.

Calculate:

a) The change in enthalpy for this **reaction** *[T/I, 2]*

b) the molar enthalpy of solution of NaOH *[T/I, 2]*

j. 16. When NH_3 is treated with oxygen gas, the products obtained are $N_2(g)$ and $H_2O(l)$. If standard enthalpies of formation at 298 K for $NH_3(g)$ and $H_2O(l)$ are –46.00 kJ/mol and –286.0 kJ/mol respectively, calculate the enthalpy change of the reaction.

[T/I, 4]

17. Phosphorous trichloride (PCl_3) is the most important chloride of phosphorus. It has extensive applications in the preparation of herbicides, insecticides, plasticizers, oil additives, etc. It can be formed as: $PCl_5(g) \rightarrow PCl_3(g) + Cl_2(g)$. Calculate, using the following data, the enthalpy change for the formation of phosphorous trichloride:
(i) $4PCl_3(g) \rightarrow P_4(s) + 6Cl_2(g) \quad \Delta H^o = 2168$ kJ
(ii) $P_4(s) + 10Cl_2(g) \rightarrow 4PCl_5(g) \quad \Delta H^o = -3056$ kJ

[T/I, 4]

18. Find $\Delta H°$ for the reaction $2C(s) + \frac{1}{2}O_2(g) + 3H_2(g) \rightarrow C_2H_5OH(\ell)$ by using the following thermochemical data.

$C_2H_5OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l)$ $\quad \Delta_r H° = -1360$ kJ

$C(s) + O_2(g) \rightarrow CO_2(g)$ $\quad \Delta_r H° = -393.9$ kJ

$H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l)$ $\quad \Delta_r H° = -286$ kJ *[T/I, 4]*

SECTION 3: Long Answer

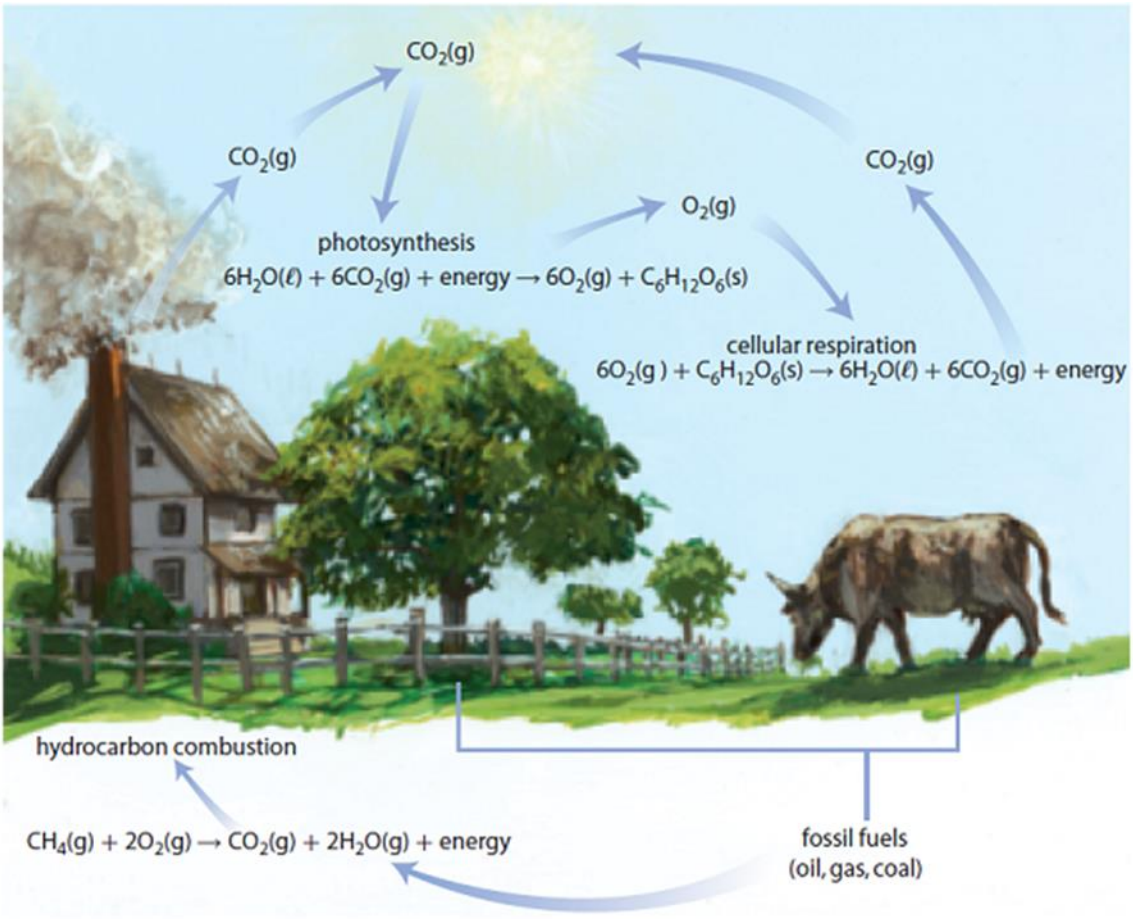
The following questions will be graded according to the following rubric:

Criteria	Level 4	Level 3	Level 2	Level 1
APPLICATION Making connections between science, technology, society, and environment	makes connections between science, technology, society, and the environment with a high degree of effectiveness **(3 marks)**	makes connections between science, technology, society, and the environment with considerable effectiveness **(2 marks)**	makes connections between science, technology, society, and the environment with some effectiveness **(1 mark)**	makes connections between science, technology, society, and the environment with limited effectiveness **(0 - 0.5 mark)**
COMMUNICATION Information and ideas are communicated with complete and correct answers	Information and ideas are communicated clearly and precisely **(2 mark)**	Information and ideas are communicated with considerable clarity and precision **(0.1 marks)**	Information and ideas are communicated with some clarity and precision **(0.5 marks)**	Information and ideas are communicated limited clarity and precision **(0 marks)**

19. The industrial production of ammonia changed the world. Ammonia is an integral ingredient of fertilizer, which allows for increased crop yield to feed our growing world population. Outline the manipulations that could be used to increase the rate of the creation of ammonia by this chemical reaction:

$N_2(g) + 3\ H_2(g) \rightarrow 2\ NH_3(g) \quad \Delta H = -92.3\ kJ$ *[A, 3; C, 2]*

20. *Through photosynthesis, green plants and blue green algae absorb energy from sunlight and store it in the chemical bonds of the carbohydrates. Animals eat these plants and store this energy by the process of cellular respiration. After plants and animal die, their remains get transformed into the hydrocarbons that form fossil fuels.*



Explain which processes described above are endothermic or exothemic. Include an explanation of the enthalpies of the products and reactants in each case. Also, explain which processes may be thought of as opposites. *[3A, 2C]*

REFERENCE RESOURCES:

Standard Enthalpies of Formation (kJ)

$2Ag_{(s)} + ½O_{2(g)} \longrightarrow Ag_2O_{(s)}$	-30.66
$C_{(s)} + 2H_{2(g)} \longrightarrow CH_{4(g)}$	-75.18
$2C_{(s)} + 3\ H_{2(g)} \longrightarrow C_2H_{6(g)}$	-84.84
$3C_{(s)} + 4H_{2(g)} \longrightarrow C_3H_{8(g)}$	-104.16
$6C_{(s)} + 3H_{2(g)} \longrightarrow C_6H_{6(g)}$	83.24
$6C_{(s)} + 3H_{2(g)} \longrightarrow C_6H_{6(l)}$	48.85
$Ca_{(s)} + ½O_{2(g)} \longrightarrow CaO_{(s)}$	-637.98
$Ca_{(s)} + O_{2(g)} + H_{2(g)} \longrightarrow Ca(OH)_{2(s)}$	-990.36
$C_{(s)} + 2H_{2(g)} + ½O_{2(g)} \longrightarrow CH_3OH_{(g)}$	-202.02
$C_{(s)} + H_2O_{(g)} \longrightarrow CO_{(g)} + H_{2(g)}$	131.40
$C_{(s)} + ½O_{2(g)} \longrightarrow CO_{(g)}$	-110.94
$C_{(s)} + O_{2(g)} \longrightarrow CO_{2(g)}$	-394.90
$CO_{(g)} + ½O_{2(g)} \longrightarrow CO_{2(g)}$	-283.92
$Cu_{(s)} + ½O_{2(g)} \longrightarrow CuO_{(s)}$	-155.82
$2Cu_{(s)} + ½O_{2(g)} \longrightarrow Cu_2O_{(s)}$	-167.16
$2Fe_{(s)} + 3/2O_{2(g)} \longrightarrow Fe_2O_{3(s)}$	-825.30
$½H_{2(g)} + ½Br_{2(l)} \longrightarrow HBr_{(g)}$	-36.37
$½H_{2(g)} + ½Cl_{2(g)} \longrightarrow HCl_{(g)}$	-92.65
$½H_{2(g)} + ½F_{2(g)} \longrightarrow HF_{(g)}$	-541.80
$½H_{2(g)} + ½I_{2(s)} \longrightarrow HI_{(g)}$	26.04
$½H_{2(g)} + ½I_{2(g)} \longrightarrow HI_{(g)}$	-5.04
$H_{2(g)} + ½O_{2(g)} \longrightarrow H_2O_{(g)}$	-242.76
$H_{2(g)} + ½O_{2(g)} \longrightarrow H_2O_{(l)}$	-283.46
$H_{2(g)} + ½O_{2(g)} \longrightarrow H_2O_{(s)}$	-289.47
$H_{2(g)} + S_{(s)} \longrightarrow H_2S_{(g)}$	-20.24
$Hg_{(l)} + ½O_{2(g)} \longrightarrow HgO_{(s)}$	-91.14
$Mg_{(s)} + ½O_{2(g)} \longrightarrow MgO_{(s)}$	-603.96
$Na_{(s)} + ½Cl_{2(g)} \longrightarrow NaCl_{(s)}$	-412.44
$Na_{(s)} + ½Cl_{2(g)} + 3/2O_{2(g)} \longrightarrow NaClO_{3(s)}$	-359.94
$½N_{2(g)} + 3/2H_{2(g)} \longrightarrow NH_{3(g)}$	-46.29
$½N_{2(g)} + 2H_{2(g)} + ½Cl_{2(g)} \longrightarrow NH_4Cl_{(s)}$	-316.60
$½N_{2(g)} + ½O_{2(g)} \longrightarrow NO_{(g)}$	90.72
$½N_{2(g)} + O_{2(g)} \longrightarrow NO_{2(g)}$	34.00
$S_{(s)} + O_{2(g)} \longrightarrow SO_{2(g)}$	-297.19
$S_{(s)} + 3/2O_{2(g)} \longrightarrow SO_{3(g)}$	-396.69
$^1/_8\ S_{8(s)} + O_{2(g)} \longrightarrow SO_{2(g)}$	-298.20
$^1/_8\ S_{8(s)} + H_{2(g)} + 2O_{2(g)} \longrightarrow H_2SO_{4(l)}$	-814.80

C6 Standard Molar Entropies and Enthalpies of Formation

Chemical Name	Formula	ΔH_f° (kJ/mol)	S° (J/(mol·K))	Chemical Name	Formula	ΔH_f° (kJ/mol)	S° (J/(mol·K))
acetone	$(CH_3)_2CO_{(l)}$	−248.1	198.8	carbon disulfide	$CS_{2(l)}$	+89.0	—
aluminum oxide	$Al_2O_{3(s)}$	−1675.7	50.92	carbon monoxide	$CO_{(g)}$	−110.5	197.66
ammonia	$NH_{3(g)}$	−45.9	192.78	chloroethene	$C_2H_3Cl_{(g)}$	+37.3	263.9
ammonium chloride	$NH_4Cl_{(s)}$	−314.4	94.6	chromium(III) oxide	$Cr_2O_{3(s)}$	−1139.7	81.2
ammonium chloride	$NH_4Cl_{(aq)}$	−299.7	169.9	copper(I) oxide	$Cu_2O_{(s)}$	−168.6	93.1
ammonium nitrate	$NH_4NO_{3(s)}$	−365.6	151.08	copper(II) oxide	$CuO_{(s)}$	−157.3	42.6
barium carbonate	$BaCO_{3(s)}$	−1216.3	112.1	copper(I) sulfide	$Cu_2S_{(s)}$	−79.5	120.9
barium hydroxide	$Ba(OH)_{2(s)}$	−944.7	107	copper(II) sulfide	$CuS_{(s)}$	−53.1	66.5
barium oxide	$BaO_{(s)}$	−553.5	72.07	cyclopropane	$C_3H_{6(g)}$	+17.8	—
barium sulfate	$BaSO_{4(s)}$	−1473.2	132.2	1,2-dichloroethane	$C_2H_4Cl_{2(l)}$	−126.9	—
benzene	$C_6H_{6(l)}$	+49.0	173.4	ethane	$C_2H_{6(g)}$	−83.8	229.1
bromine (vapour)	$Br_{2(g)}$	+30.9	245.47	1,2-ethanediol	$C_2H_4(OH)_{2(l)}$	−454.8	163.2
butane	$C_4H_{10(g)}$	−125.6	310.1	ethanoic (acetic) acid	$CH_3COOH_{(l)}$	−432.8	159.9
calcium carbonate	$CaCO_{3(s)}$	−1206.9	91.7	ethanol	$C_2H_5OH_{(l)}$	−235.2	161.0
calcium chloride	$CaCl_{2(s)}$	−795.8	104.6	ethanol	$C_2H_5OH_{(g)}$	−235.2	282.70
calcium hydroxide	$Ca(OH)_{2(s)}$	−986.1	83.4	ethene (ethylene)	$C_2H_{4(g)}$	+52.5	219.3
calcium oxide	$CaO_{(s)}$	−634.9	38.1	ethyne (acetylene)	$C_2H_{2(g)}$	+228.2	201.0
calcium sulphate	$CaSO_{4(s)}$	−1434.1	108.4	glucose	$C_6H_{12}O_{6(s)}$	−1273.1	212.1
carbon dioxide	$CO_{2(g)}$	−393.5	213.78				

Chemical Name	Formula	ΔH_f° (kJ/mol)	S° (J/(mol·K))
hexane	$C_6H_{14(l)}$	−198.7	296.1
hydrazine	$N_2H_{4(g)}$	+95.4	237.11
hydrazine	$N_2H_{4(l)}$	50.6	121.2
hydrogen bromide	$HBr_{(g)}$	−36.3	198.70
hydrogen chloride	$HCl_{(g)}$	−92.3	186.90
hydrogen cyanide	$HCN_{(g)}$	+135.1	201.81
hydrogen iodide	$HI_{(g)}$	+26.5	206.59
hydrogen peroxide	$H_2O_{2(l)}$	−187.8	109.6
hydrogen sulfide	$H_2S_{(g)}$	−20.6	205.81
iodine (vapour)	$I_{2(g)}$	+62.4	180.79
iron(III) oxide	$Fe_2O_{3(s)}$	−824.2	87.40
iron(II, III) oxide	$Fe_3O_{4(s)}$	−1118.4	145.27
lead(II) oxide	$PbO_{(s)}$	−219.0	66.5
lead(IV) oxide	$PbO_{2(s)}$	−277.4	68.60
magnesium carbonate	$MgCO_{3(s)}$	−1095.8	65.7
magnesium chloride	$MgCl_{2(s)}$	−641.3	89.63
magnesium hydroxide	$Mg(OH)_{2(s)}$	−924.5	63.24
magnesium oxide	$MgO_{(s)}$	−601.6	26.95
manganese(II) oxide	$MnO_{(s)}$	−385.2	59.8
manganese(IV) oxide	$MnO_{2(s)}$	−520.0	53.1
mercury	$Hg_{(l)}$	0.0	75.90
mercury	$Hg_{(g)}$	61.4	174.97
mercury(II) oxide	$HgO_{(s)}$	−90.8	70.25
mercury(II) sulfide	$HgS_{(s)}$	−58.2	82.4
methanal (formaldehyde)	$CH_2O_{(g)}$	−108.6	218.8
methane	$CH_{4(g)}$	−74.4	186.3
methanoic (formic) acid	$HCOOH_{(l)}$	−425.1	129.0
methanol	$CH_3OH_{(l)}$	−239.1	126.8
methylpropane	$C_4H_{10(g)}$	−134.2	294.6
nickel(II) oxide	$NiO_{(s)}$	−239.7	38.00
nitric acid	$HNO_{3(l)}$	−174.1	155.60
nitrogen dioxide	$NO_{2(g)}$	+33.2	240.1
nitrogen monoxide	$NO_{(g)}$	+90.2	210.76
nitromethane	$CH_3NO_{2(l)}$	−113.1	171.8
octane	$C_8H_{18(l)}$	−250.1	—
ozone	$O_{3(g)}$	+142.7	163.2
pentane	$C_5H_{12(l)}$	−173.5	262.7
phenylethene (styrene)	$C_6H_5CHCH_{2(l)}$	+103.8	237.6
phosphorus pentachloride	$PCl_{5(g)}$	−443.5	364.6
phosphorus trichloride	$PCl_{3(l)}$	−319.7	217.2
phosphorus trichloride	$PCl_{3(g)}$	−287.0	311.8
potassium	$K_{(s)}$	0.0	75.90
potassium	$K_{(l)}$	2.3	71.46
potassium chlorate	$KClO_{3(s)}$	−397.7	143.1
potassium chloride	$KCl_{(s)}$	−436.7	82.55
potassium hydroxide	$KOH_{(s)}$	−424.8	78.9
propane	$C_3H_{8(g)}$	−104.7	270.2
silicon dioxide	$SiO_{2(s)}$	−910.7	41.46
silver bromide	$AgBr_{(s)}$	−100.4	107.11
silver chloride	$AgCl_{(s)}$	−127.0	96.25
silver iodide	$AgI_{(s)}$	−61.8	115.5
sodium bromide	$NaBr_{(s)}$	−361.1	86.82
sodium chloride	$NaCl_{(s)}$	−411.2	115.5
sodium hydroxide	$NaOH_{(s)}$	−425.6	64.4
sodium iodide	$NaI_{(s)}$	−287.8	98.50
sucrose	$C_{12}H_{22}O_{11(s)}$	−2225.5	360.2
sulfur dioxide	$SO_{2(g)}$	−296.8	248.22
sulfur trioxide (liquid)	$SO_{3(l)}$	−441.0	—
sulfur trioxide (vapour)	$SO_{3(g)}$	−395.7	256.77
sulfuric acid	$H_2SO_{4(l)}$	−814.0	156.90
tin(II) oxide	$SnO_{(s)}$	−280.7	57.17
tin(IV) oxide	$SnO_{2(s)}$	−577.6	49.04
2,2,4-trimethylpentane	$C_8H_{18(l)}$	−259.2	328.0
urea	$CO(NH_2)_{2(s)}$	−333.5	104.6
water (liquid)	$H_2O_{(l)}$	−285.8	69.95
water (vapour)	$H_2O_{(g)}$	−241.8	188.84
zinc oxide	$ZnO_{(s)}$	−350.5	43.65
zinc sulfide	$ZnS_{(s)}$	−206.0	57.7

- Standard molar enthalpies (heats) of formation are measured at SATP (25°C and 100 kPa). The values were obtained from *The CRC Handbook of Chemistry and Physics*, 71st Edition.
- The standard molar enthalpies of elements in their standard states are defined as zero.

Periodic Table

Atomic masses are listed underneath each element

1 IA												13 IIIA	14 IVA	15 VA	16 VIA	17 VIIA	18 VIIIA
1 H 1.01	2 IIA																2 He 4.00
3 Li 6.94	4 Be 9.01											5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.00	10 Ne 20.18
11 Na 22.99	12 Mg 24.31	3 IIIB	4 IVB	5 VB	6 VIB	7 VIIB	8	9 VIIIB	10	11 IB	12 IIB	13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.07	17 Cl 35.45	18 Ar 39.95
19 K 39.1	20 Ca 40.08	21 Sc 44.96	22 Ti 47.88	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.69	29 Cu 63.55	30 Zn 65.39	31 Ga 69.72	32 Ge 72.61	33 As 74.92	34 Se 78.96	35 Br 79.90	36 Kr 83.80
37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.94	43 Tc (98)	44 Ru 101.07	45 Rh 102.91	46 Pd 106.42	47 Ag 107.87	48 Cd 112.41	49 In 114.82	50 Sn 118.71	51 Sb 121.76	52 Te 127.6	53 I 126.9	54 Xe 131.29
55 Cs 132.9	56 Ba 137.3	57 La* 138.9	72 Hf 178.5	73 Ta 180.9	74 W 183.9	75 Re 186.2	76 Os 190.2	77 Ir 192.2	78 Pt 195.1	79 Au 197.0	80 Hg 200.6	81 Tl 204.4	82 Pb 207.2	83 Bi 209	84 Po (209)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra (226)	89 Ac^ (227)	104 Rf (261)	105 Db (262)	106 Sg (263)	107 Bh (264)	108 Hs (265)	109 Mt (268)	110 Ds (271)	111 Rg (272)							

*	58 Ce 140.1	59 Pr 140.9	60 Nd 144.2	61 Pm (145)	62 Sm 150.4	63 Eu 152.0	64 Gd 157.3	65 Tb 158.9	66 Dy 162.5	67 Ho 164.9	68 Er 167.3	69 Tm 168.9	70 Yb 173.0	71 Lu 175.0
^	90 Th 232.0	91 Pa (231)	92 U 238.0	93 Np (237)	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (252)	100 Fm (257)	101 Md (258)	102 No (259)	103 Lr (260)