

SCH4U Unit 3 - Practice Questions B**SECTION 1: Short Answer**

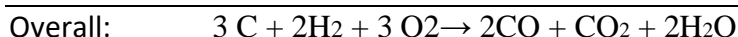
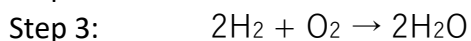
11. Identify each of the following as an endothermic or exothermic reaction:

- (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

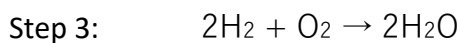
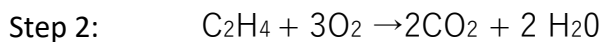
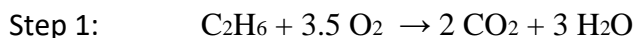
A proposed three-step mechanism is:



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

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

13. Consider the following reaction mechanism



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 were 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:

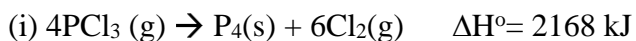
- a) The change in enthalpy for this **reaction** [T/I, 2]

- 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 $\text{N}_2(\text{g})$ and $\text{H}_2\text{O}(\text{l})$. If standard enthalpies of formation at 298 K for $\text{NH}_3(\text{g})$ and $\text{H}_2\text{O}(\text{l})$ are -46.00 kJ/mol and -286.0 kJ/mol respectively, calculate the enthalpy change of the reaction.

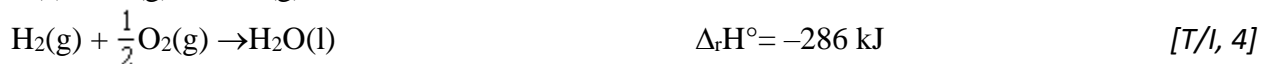
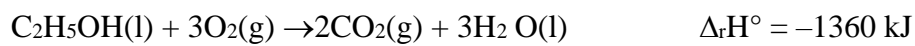
[T/I, 4]

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: $\text{PCl}_5(\text{g}) \rightarrow \text{PCl}_3(\text{g}) + \text{Cl}_2(\text{g})$. Calculate, using the following data, the enthalpy change for the formation of phosphorous trichloride:



[T/I, 4]

18. Find ΔH° for the reaction $2\text{C}(\text{s}) + \frac{1}{2}\text{O}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightarrow \text{C}_2\text{H}_5\text{OH}(\ell)$ by using the following thermochemical data.



SECTION 3: Long Answer

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

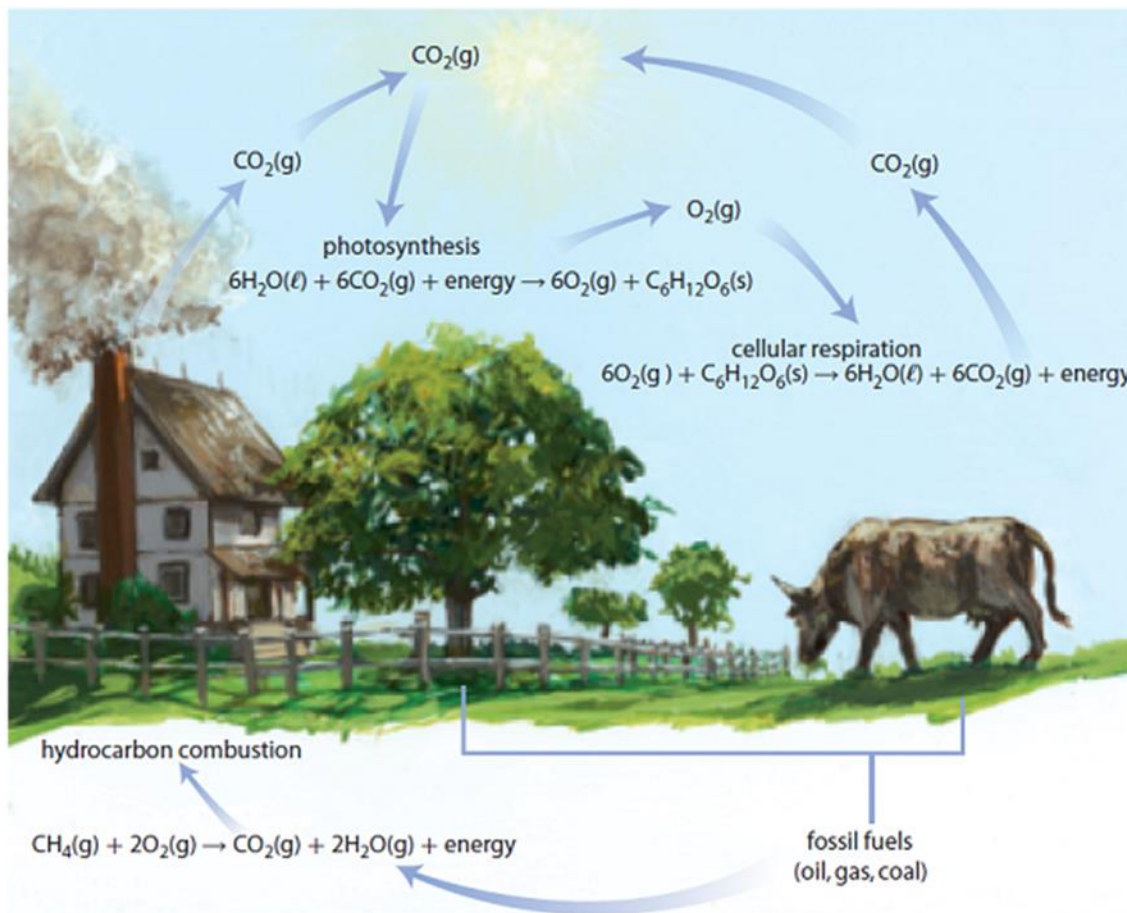
Criteria	Level 4	Level 3	Level 2	Level 1
APPLICATION Making connections between science, technology, society, and environment	makes connections between science, technology, society, and the environment with a high degree of effectiveness (3 marks)	makes connections between science, technology, society, 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:



[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 exothermic. 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)

$2\text{Ag}_{(s)} + \frac{1}{2}\text{O}_{2(g)} \longrightarrow \text{Ag}_2\text{O}_{(s)}$	-30.66
$\text{C}_{(s)} + 2\text{H}_{2(g)} \longrightarrow \text{CH}_{4(g)}$	-75.18
$2\text{C}_{(s)} + 3\text{H}_{2(g)} \longrightarrow \text{C}_2\text{H}_{6(g)}$	-84.84
$3\text{C}_{(s)} + 4\text{H}_{2(g)} \longrightarrow \text{C}_3\text{H}_{8(g)}$	-104.16
$6\text{C}_{(s)} + 3\text{H}_{2(g)} \longrightarrow \text{C}_6\text{H}_6(g)$	83.24
$6\text{C}_{(s)} + 3\text{H}_{2(g)} \longrightarrow \text{C}_6\text{H}_6(l)$	48.85
$\text{Ca}_{(s)} + \frac{1}{2}\text{O}_{2(g)} \longrightarrow \text{CaO}_{(s)}$	-637.98
$\text{Ca}_{(s)} + \text{O}_{2(g)} + \text{H}_{2(g)} \longrightarrow \text{Ca(OH)}_{2(s)}$	-990.36
$\text{C}_{(s)} + 2\text{H}_{2(g)} + \frac{1}{2}\text{O}_{2(g)} \longrightarrow \text{CH}_3\text{OH}_{(g)}$	-202.02
$\text{C}_{(s)} + \text{H}_2\text{O}_{(g)} \longrightarrow \text{CO}_{(g)} + \text{H}_{2(g)}$	131.40
$\text{C}_{(s)} + \frac{1}{2}\text{O}_{2(g)} \longrightarrow \text{CO}_{(g)}$	-110.94
$\text{C}_{(s)} + \text{O}_{2(g)} \longrightarrow \text{CO}_{2(g)}$	-394.90
$\text{CO}_{(g)} + \frac{1}{2}\text{O}_{2(g)} \longrightarrow \text{CO}_{2(g)}$	-283.92
$\text{Cu}_{(s)} + \frac{1}{2}\text{O}_{2(g)} \longrightarrow \text{CuO}_{(s)}$	-155.82
$2\text{Cu}_{(s)} + \frac{1}{2}\text{O}_{2(g)} \longrightarrow \text{Cu}_2\text{O}_{(s)}$	-167.16
$2\text{Fe}_{(s)} + 3/2\text{O}_{2(g)} \longrightarrow \text{Fe}_2\text{O}_3(s)$	-825.30
$\frac{1}{2}\text{H}_{2(g)} + \frac{1}{2}\text{Br}_{2(l)} \longrightarrow \text{HBr}_{(g)}$	-36.37
$\frac{1}{2}\text{H}_{2(g)} + \frac{1}{2}\text{Cl}_{2(g)} \longrightarrow \text{HCl}_{(g)}$	-92.65
$\frac{1}{2}\text{H}_{2(g)} + \frac{1}{2}\text{F}_{2(g)} \longrightarrow \text{HF}_{(g)}$	-541.80
$\frac{1}{2}\text{H}_{2(g)} + \frac{1}{2}\text{I}_{2(s)} \longrightarrow \text{HI}_{(g)}$	26.04
$\frac{1}{2}\text{H}_{2(g)} + \frac{1}{2}\text{I}_{2(g)} \longrightarrow \text{HI}_{(g)}$	-5.04
$\text{H}_{2(g)} + \frac{1}{2}\text{O}_{2(g)} \longrightarrow \text{H}_2\text{O}_{(g)}$	-242.76
$\text{H}_{2(g)} + \frac{1}{2}\text{O}_{2(g)} \longrightarrow \text{H}_2\text{O}_{(l)}$	-283.46
$\text{H}_{2(g)} + \frac{1}{2}\text{O}_{2(g)} \longrightarrow \text{H}_2\text{O}_{(s)}$	-289.47
$\text{H}_{2(g)} + \text{S}_{(s)} \longrightarrow \text{H}_2\text{S}_{(g)}$	-20.24
$\text{Hg}_{(l)} + \frac{1}{2}\text{O}_{2(g)} \longrightarrow \text{HgO}_{(s)}$	-91.14
$\text{Mg}_{(s)} + \frac{1}{2}\text{O}_{2(g)} \longrightarrow \text{MgO}_{(s)}$	-603.96
$\text{Na}_{(s)} + \frac{1}{2}\text{Cl}_{2(g)} \longrightarrow \text{NaCl}_{(s)}$	-412.44
$\text{Na}_{(s)} + \frac{1}{2}\text{Cl}_{2(g)} + 3/2\text{O}_{2(g)} \longrightarrow \text{NaClO}_3(s)$	-359.94
$\frac{1}{2}\text{N}_{2(g)} + 3/2\text{H}_{2(g)} \longrightarrow \text{NH}_3(g)$	-46.29
$\frac{1}{2}\text{N}_{2(g)} + 2\text{H}_{2(g)} + \frac{1}{2}\text{Cl}_{2(g)} \longrightarrow \text{NH}_4\text{Cl}_{(s)}$	-316.60
$\frac{1}{2}\text{N}_{2(g)} + \frac{1}{2}\text{O}_{2(g)} \longrightarrow \text{NO}_{(g)}$	90.72
$\frac{1}{2}\text{N}_{2(g)} + \text{O}_{2(g)} \longrightarrow \text{NO}_2(g)$	34.00
$\text{S}_{(s)} + \text{O}_{2(g)} \longrightarrow \text{SO}_2(g)$	-297.19
$\text{S}_{(s)} + 3/2\text{O}_{2(g)} \longrightarrow \text{SO}_3(g)$	-396.69
$\frac{1}{8}\text{S}_8(s) + \text{O}_2(g) \longrightarrow \text{SO}_2(g)$	-298.20
$\frac{1}{8}\text{S}_8(s) + \text{H}_2(g) + 2\text{O}_2(g) \longrightarrow \text{H}_2\text{SO}_4(l)$	-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) ₂ CO _(l)	-248.1	198.8	carbon disulfide	CS _{2(l)}	+89.0	-
aluminum oxide	Al ₂ O _{3(s)}	-1675.7	50.92	carbon monoxide	CO _(g)	-110.5	197.66
ammonia	NH _{3(g)}	-45.9	192.78	chloroethene	C ₂ H ₃ Cl _(g)	+37.3	263.9
ammonium chloride	NH ₄ Cl _(s)	-314.4	94.6	chromium(III) oxide	Cr ₂ O _{3(s)}	-1139.7	81.2
ammonium chloride	NH ₄ Cl _(aq)	-299.7	169.9	copper(I) oxide	Cu ₂ O _(s)	-168.6	93.1
ammonium nitrate	NH ₄ NO _{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 ₂ S _(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 ₃ H _{6(g)}	+17.8	-
barium sulfate	BaSO _{4(s)}	-1473.2	132.2	1,2-dichloroethane	C ₂ H ₄ Cl _{2(l)}	-126.9	-
benzene	C ₆ H _{6(l)}	+49.0	173.4	ethane	C ₂ H _{6(g)}	-83.8	229.1
bromine (vapour)	Br _{2(g)}	+30.9	245.47	1,2-ethanediol	C ₂ H ₄ (OH) _{2(l)}	-454.8	163.2
butane	C ₄ H _{10(g)}	-125.6	310.1	ethanoic (acetic) acid	CH ₃ COOH _(l)	-432.8	159.9
calcium carbonate	CaCO _{3(s)}	-1206.9	91.7	ethanol	C ₂ H ₅ OH _(l)	-235.2	161.0
calcium chloride	CaCl _{2(s)}	-795.8	104.6	ethanol	C ₂ H ₅ OH _(g)	-235.2	282.70
calcium hydroxide	Ca(OH) _{2(s)}	-986.1	83.4	ethene (ethylene)	C ₂ H _{4(g)}	+52.5	219.3
calcium oxide	CaO _(s)	-634.9	38.1	ethyne (acetylene)	C ₂ H _{2(g)}	+228.2	201.0
calcium sulphate	CaSO _{4(s)}	-1434.1	108.4	glucose	C ₆ H 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))	Chemical Name	Formula	ΔH_f° (kJ/mol)	S° (J/(mol·K))
hexane	$C_6H_{14(l)}$	-198.7	296.1	pentane	$C_5H_{12(l)}$	-173.5	262.7
hydrazine	$N_2H_{4(g)}$	+95.4	237.11	phenylethene (styrene)	$C_6H_5CHCH_2(l)$	+103.8	237.6
hydrazine	$N_2H_{4(l)}$	50.6	121.2	phosphorus pentachloride	$PCl_{5(g)}$	-443.5	364.6
hydrogen bromide	$HBr_{(g)}$	-36.3	198.70	phosphorus trichloride	$PCl_{3(l)}$	-319.7	217.2
hydrogen chloride	$HCl_{(g)}$	-92.3	186.90	phosphorus trichloride	$PCl_{3(g)}$	-287.0	311.8
hydrogen cyanide	$HCN_{(g)}$	+135.1	201.81	potassium	$K_{(s)}$	0.0	75.90
hydrogen iodide	$HI_{(g)}$	+26.5	206.59	potassium	$K_{(l)}$	2.3	71.46
hydrogen peroxide	$H_2O_{2(l)}$	-187.8	109.6	potassium chlorate	$KClO_{3(s)}$	-397.7	143.1
hydrogen sulfide	$H_2S_{(g)}$	-20.6	205.81	potassium chloride	$KCl_{(s)}$	-436.7	82.55
iodine (vapour)	$I_{2(g)}$	+62.4	180.79	potassium hydroxide	$KOH_{(s)}$	-424.8	78.9
iron(III) oxide	$Fe_2O_{3(s)}$	-824.2	87.40	propane	$C_3H_{8(g)}$	-104.7	270.2
iron(II, III) oxide	$Fe_3O_{4(s)}$	-1118.4	145.27	silicon dioxide	$SiO_{2(s)}$	-910.7	41.46
lead(II) oxide	$PbO_{(s)}$	-219.0	66.5	silver bromide	$AgBr_{(s)}$	-100.4	107.11
lead(IV) oxide	$PbO_{2(s)}$	-277.4	68.60	silver chloride	$AgCl_{(s)}$	-127.0	96.25
magnesium carbonate	$MgCO_{3(s)}$	-1095.8	65.7	silver iodide	$AgI_{(s)}$	-61.8	115.5
magnesium chloride	$MgCl_{2(s)}$	-641.3	89.63	sodium bromide	$NaBr_{(s)}$	-361.1	86.82
magnesium hydroxide	$Mg(OH)_{2(s)}$	-924.5	63.24	sodium chloride	$NaCl_{(s)}$	-411.2	115.5
magnesium oxide	$MgO_{(s)}$	-601.6	26.95	sodium hydroxide	$NaOH_{(s)}$	-425.6	64.4
manganese(II) oxide	$MnO_{(s)}$	-385.2	59.8	sodium iodide	$NaI_{(s)}$	-287.8	98.50
manganese(IV) oxide	$MnO_{2(s)}$	-520.0	53.1	sucrose	$C_{12}H_{22}O_{11(s)}$	-2225.5	360.2
mercury	$Hg_{(l)}$	0.0	75.90	sulfur dioxide	$SO_{2(g)}$	-296.8	248.22
mercury	$Hg_{(g)}$	61.4	174.97	sulfur trioxide (liquid)	$SO_{3(l)}$	-441.0	-
mercury(II) oxide	$HgO_{(s)}$	-90.8	70.25	sulfur trioxide (vapour)	$SO_{3(g)}$	-395.7	256.77
mercury(II) sulfide	$HgS_{(s)}$	-58.2	82.4	sulfuric acid	$H_2SO_{4(l)}$	-814.0	156.90
methanal (formaldehyde)	$CH_2O_{(g)}$	-108.6	218.8	tin(II) oxide	$SnO_{(s)}$	-280.7	57.17
methane	$CH_{4(g)}$	-74.4	186.3	tin(IV) oxide	$SnO_{2(s)}$	-577.6	49.04
methanoic (formic) acid	$HCOOH_{(l)}$	-425.1	129.0	2,2,4-trimethylpentane	$C_8H_{18(l)}$	-259.2	328.0
methanol	$CH_3OH_{(l)}$	-239.1	126.8	urea	$CO(NH_2)_{2(s)}$	-333.5	104.6
methylpropane	$C_4H_{10(g)}$	-134.2	294.6	water (liquid)	$H_2O_{(l)}$	-285.8	69.95
nickel(II) oxide	$NiO_{(s)}$	-239.7	38.00	water (vapour)	$H_2O_{(g)}$	-241.8	188.84
nitric acid	$HNO_{3(l)}$	-174.1	155.60	zinc oxide	$ZnO_{(s)}$	-350.5	43.65
nitrogen dioxide	$NO_{2(g)}$	+33.2	240.1	zinc sulfide	$ZnS_{(s)}$	-206.0	57.7
nitrogen monoxide	$NO_{(g)}$	+90.2	210.76	<ul style="list-style-type: none"> Standard molar enthalpies (heats) of formation are measured at SATP (25°C and 100 kPa). The values were obtained from <i>The CRC Handbook of Chemistry and Physics</i>, 71st Edition. The standard molar enthalpies of elements in their standard states are defined as zero. 			
nitromethane	$CH_3NO_{2(l)}$	-113.1	171.8				
octane	$C_8H_{18(l)}$	-250.1	-				
ozone	$O_{3(g)}$	+142.7	163.2				

Periodic Table

Atomic masses are listed underneath each element

1 IA																			18 VIIIA
1 H 1.01	2 IIA											13 IIIA	14 IVA	15 VA	16 VIA	17 VIIA	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 VIII B	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	59	60	61	62	63	64	65	66	67	68	69	70	71
*	Ce 140.1	Pr 140.9	Nd 144.2	Pm (145)	Sm 150.4	Eu 152.0	Gd 157.3	Tb 158.9	Dy 162.5	Ho 164.9	Er 167.3	Tm 168.9	Yb 173.0	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)