TMSCA HIGH SCHOOL

SCIENCE

TEST #4©

NOVEMBER 11, 2017

GENERAL DIRECTIONS

1. DO NOT OPEN EXAM UNTIL TOLD TO DO SO.
2. You will be given 120 minutes to take this test.
2. All answers must be written on the answer sheet/Scantron form/Chatsworth card provided. If you are using an answer sheet, be sure to use **CAPITAL BLOCK PRINTED LETTERS**.
3. If using a Scantron answer form, be sure to correctly denote the number of problems not attempted.
4. You may write anywhere on the test itself. You must write only answers on the answer sheet.
5. You may use additional scratch paper provided by the contest director.
6. All problems have **ONE** and **ONLY ONE** correct (BEST) answer. There is a penalty for all incorrect answers.
7. On the back of this page is a copy of the periodic table of the elements as well as a list of some potentially useful information in answering the questions. Other scientific relationships are listed also.
8. The following is a list of UIL approved calculators for this test:
   - **Casio FX-260 Solar**
   - **Sharp EL-501X**
   - **TI-30Xa**

   Only the models listed above are allowed during the contest. <u>NO GRAPHING CALCULATORS</u>.
9. All problems answered correctly are worth **SIX** points. **TWO** points will be deducted for all problems answered incorrectly. No points will be added or subtracted for problems not answered.
10. In case of ties, percent accuracy will be used as a tie breaker.
11. If a question is omitted, no points are given or subtracted.

B01. The alpha helix structure of a protein is stabilized by which type of interaction?

A) hydrophobic interactions
B) nonpolar covalent bonds
C) ionic bonds
D) hydrogen bonds
E) polar covalent bonds

B02. Choose the answer below that best describes the change in free energy at chemical equilibrium.

A) slightly increasing
B) greatly increasing
C) slightly decreasing
D) greatly decreasing
E) There is no net change

B03. Why are some bacteria metabolically active in extremely hot environments?

A) they are able to maintain an internal temperature much cooler than that of the surrounding water.
B) the high temperatures facilitate active metabolism without the need of catalysis
C) their enzymes have high optimal temperatures
D) their enzymes function regardless of temperature
E) they don't use proteins as their main catalysts.

B04. The movement of potassium across an animal cell membrane requires which of the following

A) low cellular concentrations of sodium.
B) high cellular concentrations of potassium
C) an energy source such as ATP or a proton gradient.
D) glucose for binding and releasing ions.
E) plant hormones embedded in the cell membrane.

B05. Which of the following types of cells are specialized for photosynthesis in leaves.

A) Companion
B) Mesophyll
C) Sclerenchyma
D) Tracheid
E) Collenchyma

B06. Choose the answer choice that is **NOT** true regarding bacterial chromosomes.

A) It is a single, circular DNA molecule
B) DNA replication begins at the origin of replication
C) Its centromeres uncouple during replication
D) It is highly folded
E) The DNA contains genes that regulate binary fission.

B07. Which of the following does not occur in mitosis, but does occur in meiosis?

A) replication of chromosomes
B) synapsis
C) production of daughter cells
D) tetrads align on the metaphase plate
E) both B and D are correct

B08. If nondisjunction occurs in meiosis II during the production of gametes, what would you expect to find at the completion of meiosis?

A) all gametes will be diploid
B) two games will be n+1 and two will be n-1
C) one gamete will be n+1, one will be n-1, and the other two will both be n
D) there will be three extra gametes
E) half of the gametes will be haploid and half will be diploid

B09. Which of the following is NOT found in prokaryotic messenger RNA?

A) start codon
B) stop codon
C) introns
D) uracil
E) cytosine

B10. When created a DNA profile which of the following is used?

A) cutting DNA with restriction enzymes
B) electrophoresis of DNA fragments
C) using a probe to locate specific nucleotide sequences
D) A and B
E) A, B and C

B11. How was Darwin's mechanism for evolution different than Lamarck's?

A) species are not fixed
B) evolution leads to adaptation
C) life on Earth has had a long evolutionary history
D) life on earth evolved gradually through minute changes
E) variations acquired during a lifetime is not as important as the inherent variations in a population

B12. Plant species Z has a diploid number of 28. Plant species X has a diploid number of 14. A new, sexually reproducing species Y arises as an allopolyploid from hybridization of A and B. The most likely diploid number of Y would be

A) 21
B) 14
C) 63
D) 42
E) 28

B13. Choose the correct sequence of evolutionary events beginning with the earliest.

I. Origin of mitochondria
II. Origin of multicellular eukaryotes
III. Origin of chloroplasts
IV. Origin of cyanobacteria
V. Origin of fungal/plant symbioses

A) 4, 3, 2, 1, 5
B) 4, 1, 2, 3, 5
C) 4, 3, 1, 2, 5
D) 4, 3, 1, 5, 2
E) 3, 4, 1, 2, 5

B14. Choose the answer choice below that was NOT a problem the first land plants had to overcome.

A) sources of water
B) sperm transfer
C) desiccation
D) animal predation
E) support to overcome gravity

B15. Several species of turtles can be found throughout the state of Texas. They can be generally grouped as basking turtles that frequently can be found out on logs and bottom dwellers that are rarely seen out of the water. Using this information a biologist would predict that which type of isolation led to the divergence between these two groups of turtles?

A) habitat
B) temporal
C) behavioral
D) gametic
E) mechanical

B16. Which of the following is NOT a characteristic of Fungi?

A) cell walls made of chitin
B) heterotrophic
C) photosynthetic
D) saprophytic
E) unicellular

B17. Which type of bond would you expect to find between a phosphate group and hydroxyl group?

A) amino
B) peptide
C) glycosidic
D) phosphodiester
E) ester

B18. Which of the following would be amphipathic?

I. phospholipid
II. integral protein
III. cellulose
IV. cholesterol

A) I only
B) I and II
C) I, II, and III
D) I and III
E) I, IV and III

B19. Which type of tissue would include blood?

A) adipose
B) cardiac
C) skeletal
D) connective
E) smooth

B20. Which of the following best describes introns, in regards to transcription?

A) the ends of the genes that shorten after each transcription event
B) genes that have jumped from one chromosome to a homologous chromosome
C) non-coding sections of a mRNA prior to splicing
D) sections of polypeptides dominated by hydrophobic alpha helices
E) the covering of a beetle's carapace

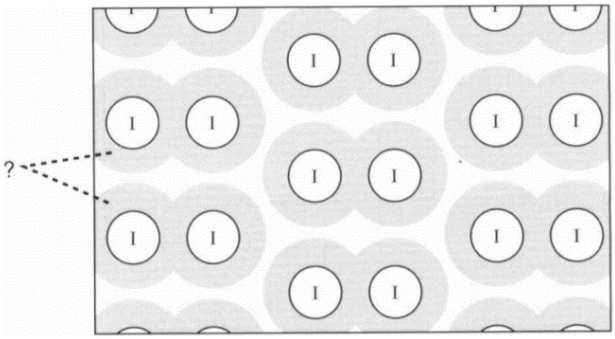
C01. What is the molar mass of iron (III) sulfide?
A) 232 g/mol
B) 398 g/mol
C) 314 g/mol
D) 208 g/mol
E) 152 g/mol

C02. The Pauli Exclusion Principle states that in an atom, no two electrons can have the same four quantum numbers. Which of the following is the result of the exclusion principle?
A) Electrons in the same orbital must have opposite spins.
B) The "s" sub-shell can hold a maximum of two electrons.
C) The "d" sub-shell can hold a maximum of 6 electrons.
D) Electrons gain energy when they jump up energy levels and lose energy when they drop down energy levels.
E) There are three "p" orbitals in a "p" sub-shell.

C03. The chemical formula of common table salt is NaCl. Which of the following best describes the bonding in solid NaCl?
A) Molecules NaCl are held together by strong dipole-dipole attraction.
B) Sodium and chloride ions are held in a crystalline lattice by electrostatic forces.
C) Molecules of NaCl are held together by weak dispersion forces.
D) Sodium and chlorine atoms are held in a crystalline lattice by a network of covalent bonds.

C04. Which of the following aqueous solutions has the lowest boiling point? Assume ideal behavior.
A) 0.20 *m* $C_{12}H_{22}O_{11}$
B) 0.15 *m* $AlCl_3$
C) 0.15 *m* NaCl
D) 0.20 *m* NaCl
E) pure water

C05. Consider the following diagram which represents a sample of solid iodine.



What is the force/bond between the iodine atoms touching the dashed line?
A) covalent bond
B) dispersion forces
C) dipole-dipole attraction
D) ionic bond
E) hydrogen bond

C06. According to the following unbalanced equation, how many grams of graphite is needed to react with 35.0 grams of $CaCO_3$?

$$CaCO_3(s) + C_{(graphite)} \rightarrow CaC_2(s) + CO_2(g)$$

A) 21.4 g
B) 13.9 g
C) 10.5 g
D) 11.7 g
E) 8.2 g

C07. For the reaction:

$$2\ NO(g) + Br_2(g) \rightarrow 2\ NOBr(g)$$

the following initial rate data were obtained:

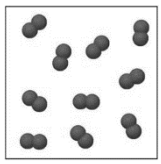
Initial [NO] (M)	Initial $[Br_2]$ (M)	Initial rate appearance [NOBr] ($M \cdot s^{-1}$)
0.10	0.20	24
0.25	0.20	150
0.10	0.50	60
0.35	0.50	735

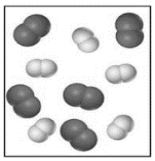
What is the rate law for the reaction?
A) rate = $k[NO][Br_2]^2$
B) rate = $k[NO][Br_2]$
C) rate = $k[NO]^2[Br_2]^2$
D) rate = $k[NO]^2$
E) rate = $k[NO]^2[Br_2]$

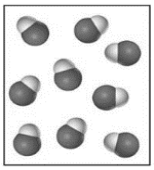
C08. Commercially available ice packs often contain a small pouch of water inside solid NH_4Cl. When the pouch is broken, the water and the NH_4Cl are mixed. Why is the process used in ice packs?

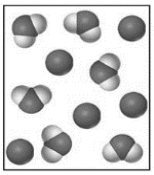
A) Dissolving NH_4Cl releases cold into the surrounding.
B) Dissolving NH_4Cl absorbs cold from the surrounding.
C) Dissolving NH_4Cl releases heat into the surrounding.
D) Dissolving NH_4Cl absorbs cold from the surrounding.

C09. Which of the following represents an element?

A) 

B) 

C) 

D) 

E) None of these

C10. Richard goes into the lab and sees two bottles containing aqueous solutions of NaCl. One bottle is 2.0-molar NaCl and the other bottle is 2.0-molal NaCl. Which of the solutions has the larger percent by mass of NaCl?

A) the 2.0-molar solution
B) the 2.0-molal solution
C) the solutions have the same percent by mass of NaCl
D) Richard needs to determine the density of the solutions to know which has a greater percent by mass.

C11. The equilibrium constant for the following reaction:

$$H_2(g) + I_2(g) \rightleftharpoons 2\ HI(g)$$

is 48.2 at 225°C. What is the value of K_{eq} for the following reaction

$$HI(g) \rightleftharpoons \frac{1}{2} H_2(g) + \frac{1}{2} I_2(g)$$

at 225°C?

A) 96.4
B) 24.1
C) −24.1
D) 0.0207
E) 0.144

C12. A solution is made by dissolving 2.4 grams of NaOH(s) into 125 mL of 0.45 M HCl(aq) What is the pH of this solution? (Assume no change in volume)

A) 6.21
B) 7.00
C) 12.52
D) 11.82
E) 10.46

C13. A solution is made by adding 50 mL of 1.0M HCl(aq) to 100 mL of 1.0 M CH_3NH_2(aq). What is the pH of the resulting solution?

A) 12.86
B) 12.32
C) 11.51
D) 10.64
E) 9.78

C14. Michael wants to dispose of some elemental iodine (I_2). He remembers that I_2 is highly reactive and needs to reduce it to I^- before disposal. Using the standard reduction potentials:

Half reaction	$E°$ (V)
$S_4O_6^{2-}(aq) + 2\ e^- \rightarrow 2\ S_2O_3^{2-}(aq)$	0.08
$I_2(s) + 2\ e^- \rightarrow 2\ I^-(aq)$	0.54
$O_2(g) + 2\ H^+(aq) + 2\ e^- \rightarrow H_2O_2(aq)$	0.68

What should Michael use to reduce the I_2?

A) H_2O_2
B) I^-
C) $S_2O_3^{2-}$
D) O_2
E) $S_4O_6^{2-}$

C15. Which of the following has the largest atomic radius?
A) F
B) Ne
C) Na
D) Mg
E) Al

C16. When 150 mL of a 0.85 M solution of lead (II) nitrate and 235 mL of 1.2 M solution of potassium iodide are mixed together, a precipitate is formed. The precipitate is filtered and dried. What is the maximum mass of the precipitate formed?
A) 59 g
B) 62 g
C) 65 g
D) 74 g
E) 78 g

C17. A solution is made placing 350 mL of 1.2 M HF(aq), 15.0 grams of NaF(s) and 1.6 grams of NaOH(s) into a container and adding water until the volume of the solution is 500. mL. What is the pH of the solution?
A) 2.78
B) 3.16
C) 4.24
D) 4.52
E) 5.02

C18. Under certain conditions, methane can undergo an incomplete combustion according to the following equation:

$$2\ CH_4(g) + 2\ O_2(g) \rightarrow CO(g) + CO_2(g) + H_2O(l) + 3\ H_2(g)$$

Given the following,

$$CO(g) + \frac{1}{2}\ O_2(g) \rightarrow CO_2(g);\ \Delta H = -284\ \text{kJ/mol}$$

determine the ΔH for the incomplete combustion of CH_4.
A) −1100 kJ/mol
B) −872 kJ/mol
C) −795 kJ/mol
D) −639 kJ/mol
E) −125 kJ/mol

C19. The rate constant for the reaction $2A \rightarrow B$ is $0.013\ s^{-1}$. The initial [A] and [B] in a sealed flask are 0.80 M and 0 M respectively. How long will it take for the [B] in the flask to reach 0.82 M?
A) 2.9 min
B) 32 sec
C) 4.2 min
D) 42 sec
E) 55 sec

C20. Molten aluminum is electrolyzed with a current of 3.2 amps for 12 hours. How many grams of Al(s) are produced by this process?
A) 14.1 g
B) 13.4 g
C) 12.9 g
D) 11.3 g
E) 10.9 g

P01. According to Neil deGrasse Tyson, the ordinary photon is a member of the _____ family.
A) fermion
B) boson
C) lepton
D) quark
E) hadron

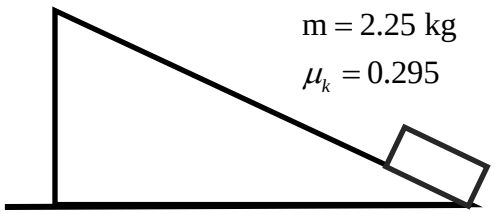
P02. According to Neil deGrasse Tyson, we cannot see the source of 85% of the gravity we measure in the universe. This mysterious _____ remains undetected except for its gravitational pull on matter that we see.
A) antimatter
B) black holes
C) group of neutron stars
D) dark matter
E) Entropic gravity

P03. According to Neil deGrasse Tyson, the CMB radiates in several parts of the electromagnetic spectrum. It peaks in the _____ portion of the EM spectrum.
A) microwave
B) infrared
C) ultraviolet
D) X-ray
E) gamma ray

P04. As soon as a 1-$M_\odot$ star exhausts the hydrogen at its core, it leaves the main sequence and begins to move upward and to the right on the H-R diagram, growing more luminous and cooler. The star is larger and somewhat brighter than when it was on the main sequence and it is now called a _____.
A) white dwarf
B) pulsar
C) supernova
D) brown dwarf
E) subgiant star

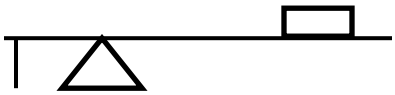
P05. As a general rule, relativistic effects should be considered once an object reaches a speed of 0.1*c* or _____ m/s. (*c* = speed of light)
A) 3.00×10^{10}
B) 3.00×10^{9}
C) 3.00×10^{8}
D) 3.00×10^{7}
E) 3.00×10^{6}

P06. A projectile is launched from the ground at an angle of 42.1º above the horizontal. It reaches a maximum height of 22.3 m. Find the initial velocity of the projectile. Ignore air resistance.
A) 26.8 m/s
B) 29.0 m/s
C) 31.2 m/s
D) 33.4 m/s
E) 35.6 m/s



P07. A wooden block is placed at the bottom of a plane inclined at an angle of 29.7º above the horizontal. A force parallel to the plane is applied to the block and it accelerates up the the incline at 1.52 m/s^2. Find the magnitude of the force.
A) 17.8 N
B) 20.0 N
C) 22.2 N
D) 24.4 N
E) 26.6 N

P08. The height of Shoshone Falls in Idaho is 64.6 m. When the water reaches the bottom of the falls, its speed is 36.4 m/s. What is the speed of the water at the top of the falls? Ignore air resistance.
A) 7.67 m/s
B) 7.43 m/s
C) 7.19 m/s
D) 6.95 m/s
E) 6.71 m/s



P09. A 50.0-kg box is placed 2.45 m from the fulcrum supporting a 4.00-m-long diving board. The left side of the board is bolted down as shown. The bolt is 80.0 cm from the fulcrum and 20.0 cm from the left end of the board. The mass of the diving board is 10.0 kg. Find the force that the fulcrum exerts on the board.
A) 1620 N
B) 1770 N
C) 1820 N
D) 1960 N
E) 2210 N

P10. Joe launched a bottle rocket on July 4 that climbed to a height of 50.0 m and exploded. People below measured the sound of the explosion to be 84.7 dB. The next identical rocket only reached a height of 40.0 m before exploding. What did this explosion measure?
A) 86.6 dB
B) 88.5 dB
C) 90.4 dB
D) 92.3 dB
E) 94.2 dB

P11. Four moles of an ideal monotonic gas expanded isothermally at a temperature of 308 K. The volume of the gas changed from 0.124 m^3 to 0.336 m^3. Find the heat supplied to the gas during the expansion.
A) 9,600 J
B) 9,900 J
C) 10,200 J
D) 10,500 J
E) 10,800 J

P12. Joe has three capacitors that have respective capacitances of 246 nF, 432 nF and 678 nF. If he connects them in series, what will the net capacitance be?
A) 1360 nF
B) 1050 nF
C) 741 nF
D) 434 nF
E) 127 nF

P13. A 14.5 μC charge is placed on the x-axis at $x = -1.33$ m. A 22.3 μC charge is placed on the x-axis at $x = 1.62$ m. Where on the x-axis is the electric field equal to zero?
A) $x = -.116$ m
B) $x = -.0515$ m
C) $x = -.0131$ m
D) $x = .0349$ m
E) $x = .0698$ m

P14. A coil of wire consists of 100 circular loops, each with a radius of 6.52 cm. A current of 2.88 A flows through the wire. The coil is placed in a uniform 0.357-T magnetic field. Find the maximum torque the magnetic field can exert on the coil.
A) 1.05 N·m
B) 1.37 N·m
C) 1.69 N·m
D) 2.10 N·m
E) 2.42 N·m

P15. A coil of wire consists of 200 loops, each with an area of 0.0450 m^2. The plane of the coil is oriented horizontally. The coil is placed in a 0.853-T magnetic field that is oriented vertically upward. If the coil is rotated at 120 rpm, what is the magnitude of the peak emf induced?
A) 86.6 V
B) 89.9 V
C) 93.2 V
D) 96.5 V
E) 99.8 V

P16. A 1.55-in-tall candle is positioned 32.0 cm from a diverging lens with a focal length of –24.0 cm. Describe the image.
A) enlarged, real, erect
B) enlarged, virtual, inverted
C) reduced, real, inverted
D) reduced, virtual, erect
E) reduced, real, erect

P17. Jo and Bo are identical twins that are 18 years old today. Jo hops on a spacecraft that travels at a speed of 0.925*c*. When Jo returns to Earth, Bo will be exactly 54 years old. How old will Jo be? (*c* = speed of light)
A) 31.7 yr
B) 33.8 yr
C) 35.9 yr
D) 38.0 yr
E) 40.1 yr

P18. Consider the gamma decay process.
$^{226}_{88}\text{Ra}^{*} \rightarrow {}^{226}_{88}\text{Ra} + \gamma$
If a 0.192 MeV gamma ray photon is emitted, what is the wavelength of the photon?
A) 88.4 nm
B) 3.17 nm
C) 692 pm
D) 34.5 pm
E) 6.46 pm

P19. An object has a mass of 0.425 kg and its momentum is 9.56 kg·m/s. What is the kinetic energy of the object?
A) 80.1 J
B) 94.2 J
C) 108 J
D) 122 J
E) 136 J

P20. A 5.62×10^{-5} kg object has a charge of 9.66×10^{-9} C. If it is placed in a 6,000 N/C electric field and released, what will the acceleration of the object be?
A) 0.850 m/s^2
B) 1.03 m/s^2
C) 1.21 m/s^2
D) 1.39 m/s^2
E) 1.57 m/s^2

Chemistry

1A 1												3A 13	4A 14	5A 15	6A 16	7A 17	8A 18
1 H 1.01	2A 2																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	3B 3	4B 4	5B 5	6B 6	7B 7	8B 8	8B 9	8B 10	1B 11	2B 12	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 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.87	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 65.38	31 Ga 69.72	32 Ge 72.64	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 127.60	53 I 126.90	54 Xe 131.29
55 Cs 132.91	56 Ba 137.33	57 La 138.9	72 Hf 178.49	73 Ta 180.95	74 W 183.84	75 Re 186.21	76 Os 190.23	77 Ir 192.22	78 Pt 195.08	79 Au 196.97	80 Hg 200.59	81 Tl 204.38	82 Pb 207.20	83 Bi 208.98	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 (266)	107 Bh (264)	108 Hs (277)	109 Mt (268)	110 Ds (281)	111 Rg (281)	112 Cn (285)	113 Nh (286)	114 Fl (289)	115 Mc (289)	116 Lv (293)	117 Ts (293)	118 Og (294)

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 231.0	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 (262)

Constants

R = 0.08206 L·atm/mol·K
R = 8.314 J/mol·K
R = 62.36 L·torr/mol·K
e = 1.602×10^{-19} C
N_A = 6.022×10^{23} mol^{-1}
k = 1.38×10^{-23} J/K
h = 6.626×10^{-34} J·s
c = 3.00×10^{8} m/s
$\mathcal{R}$ = 2.178×10^{-18} J
m_e = 9.11×10^{-31} kg

Water data

T_{mp} = 0°C
T_{bp} = 100°C
C_{ice} = 2.09 J/g K
C_{water} = 4.184 J/g K
C_{steam} = 2.03 J/g K
ΔH_{fus} = 334 J/g
ΔH_{vap} = 2260 J/g
K_f = 1.86 °C/m
K_b = 0.512 °C/m

Densities

ρair,dry = 0.001184 g/mL
ρwater = 1.00 g/mL
ρice = 0.917 g/mL
ρFe = 7.87 g/mL
ρAu = 19.3 g/mL
ρHg = 13.6 g/mL

Standard Thermodynamic Data

substance	ΔH_f^o (kJ/mol)	$S°$ (kJ/mol)
CO_2 (g)	−394	214
CH_4 (g)	−75	186
C_2H_6 (g)	−85	229
C_3H_8 (g)	−104	270
$COCl_2$ (g)	−220	284
H_2O (l)	−286	70
H_2O (g)	−242	189

Conversions

1 atm = 760 torr
= 101325 Pa
= 14.7 psi
1 bar = 105 Pa
1 cal = 4.184 J
1 L·atm = 101.325 J
1 eV = 1.602×10^{-19} J
1 lb = 453.6 g
1 ton = 2000 lbs
1 tonne = 1000 kg
1 in = 2.54 cm

Some equilibrium constants

water K_w = 1.0×10^{-14}
PbF_2 K_{sp} = 3.3×10^{-8}
HF K_a = 7.2×10^{-4}
CH_3NH_2 K_b = 4.4×10^{-4}

PHYSICS

Useful Constants

quantity	**symbol**	**value**
Free-fall acceleration	g	9.80 m/s^2
Coulomb constant	k	8.99×10^9 $N \cdot m^2/C^2$
Electron mass	m_e	9.11×10^{-31} kg
Fundamental charge	e	1.602×10^{-19} C
Speed of light in a vacuum	*c*	3.00×10^8 m/s
Density of water	ρ	1000 kg/m^3
Permeability of free space	μ_0	$4\pi \times 10^{-7}$ T·m/A
Planck's constant	h	6.626×10^{-34} J·s
Gravitational constant	G	6.67×10^{-11} $N \cdot m^2/kg^2$
Permittivity of free space	ε_0	8.854×10^{-12} $C^2/N \cdot m^2$
Electron volt	eV	1.602×10^{-19} J
Density of water	ρ_w	1000 kg/m^3
Threshold of hearing	I_0	10^{-12} W/m^2
Universal gas constant	R	8.314 J/mol·K

2017-2018 TMSCA HSSC Test #4 Answer Key

Biology		Chemistry		Physics	
B01.	D	C01.	D	P01.	B
B02.	E	C02.	A	P02.	D
B03.	C	C03.	B	P03.	A
B04.	C	C04.	B	P04.	E
B05.	B	C05.	B	P05.	D
B06.	C	C06.	C	P06.	C
B07.	E	C07.	E	P07.	B
B08.	C	C08.	D	P08.	A
B09.	C	C09.	A	P09.	E
B10.	E	C10.	A	P10.	A
B11.	E	C11.	E	P11.	C
B12.	D	C12.	C	P12.	E
B13.	C	C13.	D	P13.	C
B14.	D	C14.	C	P14.	B
B15.	A	C15.	D	P15.	D
B16.	C	C16.	A	P16.	D
B17.	D	C17.	B	P17.	A
B18.	B	C18.	D	P18.	E
B19.	D	C19.	E	P19.	C
B20.	C	C20.	C	P20.	B

SELECTED SOLUTIONS

C01. (D) iron (III) sulfide is Fe_2S_3, molar mass is $2\ mol \times 55.9\frac{g}{mol} + 3\ mol \times 32.0\frac{g}{mol} = 208\frac{g}{mol}$

C04. (B) $\Delta T_f = i \times K_f \times m$; so freezing point depends on $i \times m$. For $AlCl_3$ solution, $i \times m = 0.60$, which is the largest so it has the lowest freezing point.

C05. (B) Since I_2 is non-polar, the attraction between molecules is dispersion force.

C06. (C) The balanced equation is $2\ CaCO_3 + 5\ C \rightarrow 2\ CaC_2 + 3\ CO_2$

$35.0\ g\ CaCO_3 \times \frac{1\ mol\ CaCO_3}{100\ g} \times \frac{5\ mol\ C}{2\ mol\ CaCO_3} \times \frac{12\ g\ C}{1\ mol} = 10.5\ g$

C07. (E) Between experiments 1 & 2, the [NO] increases by 2.5 times while $[Br_2]$ is held constant and the rate increases by factor of 6.25, so NO is second order. Between experiments 1 & 3, the $[Br_2]$ increases by 2.5 times while [NO] is held constant and the rate increases by 2.5 times, so Br_2 is first order.

C10. (A) To make a 2.0-molar solution, 2.0 moles of NaCl is added to enough water to make 1 liter of solution. The NaCl occupies volume so the volume of water added is less than 1 liter. To make a 2.0-molal solution, 2.0 moles of NaCl is added to 1 kg (1 L) of water. The 2.0-molar solution is more concentrated so higher percent by mass of NaCl.

C11. (E) For the reaction: $H_2(g) + I_2(g) \rightleftharpoons 2\ HI(g)$, $K_{eq} = \frac{[HI]^2}{[H_2][I_2]} = 48.2$

For the reaction: $HI(g) \rightleftharpoons \frac{1}{2}\ H_2(g) + \frac{1}{2}\ I_2(g)$, $K_{eq} = \frac{[H_2]^{\frac{1}{2}}[I_2]^{\frac{1}{2}}}{[HI]} = \frac{1}{\sqrt{48.2}} = 0.144$

C12. (C)

R	H^+	+ OH^-	→ H_2O
I	0.056 mol	0.060 mol	
C	−0.056 mol	−0.056 mol	
E	0	0.004 mol	

Since HCl is limiting reactant, there are 0.004 mol of OH^- ions in excess.

$[OH^-] = \frac{0.004\ mol}{0.125\ L} = 0.033\ M,\ \ pOH = -log 0.033 = 1.48,\ \ pH = 14 - 1.48 = 12.52$

C13. (D) The number of moles of HCl added is equal to half the moles of CH_3NH_2. At the half equivalence point, $[CH_3NH_2] = [CH_3NH_3^+]$ and $pOH = pK_b$, $pOH = -\log(4.4\times10^{-4}) = 3.36$,
$pH = 14 - 3.36 = 10.64$

C14. (C) For reduction of I_2 to occur, either H_2O_2 or $S_2O_3^{2-}$ must be oxidized. The reaction between I_2 and $S_2O_3^{2-}$ has net positive potential, so it occurs spontaneously.

C16. (A) $Pb^{2+}(aq) + 2\ I^-(aq) \rightarrow PbI_2(s)$

$0.150\ L \times 0.85\frac{mol}{L} \times \frac{1\ mol\ PbI_2}{1\ mol\ Pb^{2+}} \times \frac{461\ g\ PbI_2}{1\ mol} = 59\ g$

$0.235\ L \times 1.2\frac{mol}{L} \times \frac{1\ mol\ PbI_2}{2\ mol\ I^-} \times \frac{461\ g\ PbI_2}{1\ mol} = 65\ g$

Pb2+ is the limiting reactant so 59 grams of precipitate is produced.

C17. (B) In the final solution:

$[HF] = 0.35L \times 1.2\frac{mol}{L} = 0.42\ mol \div 0.50\ L = 0.84M$

$mol\ NaOH = 1.6\ g \times \frac{1\ mol\ NaOH}{40\ g} = 0.04\ mol \div 0.50\ L = 0.08M$

$mol\ NaF = 15\ g \times \frac{1\ mol\ NaF}{42\ g} = 0.36\ mol \div 0.50L = 0.72M$

Neutralization:

R	HF	+ OH^-	→ H_2O	+ F^-
I	0.84 M	0.08 M		0.72 M
C	−0.08 M	−0.08 M		+0.08 M
E	0.76 M	0		0.80 M

Equilibrium:

R	HF	⇌ H^+	+ F^-
I	0.76 M	0	0.80 M
C	$-x$	$+x$	$+x$
E	$0.76 - x$	x	$0.80 + x$

$7.2 \times 10^{-4} = \frac{(x)(0.80+x)}{(0.76-x)} \approx \frac{0.80x}{0.76}$ $\quad x = 6.8 \times 10^{-4}, \quad pH = -\log(6.8 \times 10^{-4}) = 3.16$

C18. (D) For: $CO(g) + \frac{1}{2}O_2(g) \rightarrow CO_2(g)$, $\Delta H = -284$ kJ/mol $= -394$ kJ/mol $- \Delta H_f$ CO,
ΔH_f CO $= -110$ kJ/mol

For: $2\ CH_4(g) + 2\ O_2(g) \rightarrow CO(g) + CO_2(g) + H_2O(l) + 3\ H_2(g)$
$\Delta H = (-110$ kJ/mol $+ -394$ kJ/mol $+ -285$ kJ/mol$) - 2\times(-75$ kJ/mol$) =$

C19. (E) Based on units for k, the reaction is first order.
When [B] reaches 0.82 M in the flask, [A] = 0.39 M
$\ln(0.39) = -0.013s^{-1} \times t + \ln(0.80)$, $\quad t = 55\ sec$

C20. (C) $3.2\frac{C}{Sec} \times 43200\ sec \times \frac{1\ e^-}{1.602\times10^{-19}\ C} \times \frac{1\ mol\ e^-}{6.022\times10^{23}\ e^-} \times \frac{1\ mol\ Al}{3\ mol\ e^-} \times \frac{27.0\ g\ Al}{1\ mol} = 12.9\ g\ Al$

SELECTED SOLUTIONS

P1-P3 Astrophysics for People in a Hurry; Neil deGrasse Tyson; W. W. Norton & Company; 2017

P1. page 21 P2. page 43 P3. page 51

P4. 21st Century Astronomy; Kay, Palen, Smith, Blumenthal; W.W. Norton & Company; 2013; pages 497

P5. $(.1)\left(3x10^{8}\right) =$
$3x10^{7}$ m/s

P6. $d_{v\max} = \dfrac{v^2 \sin^2\theta}{2g}$

$v = \sqrt{\dfrac{(22.3)(2)(9.8)}{\sin^2(84.2°)}}$

$v = 31.2$ m/s

P7. $\sum F = ma$

$F - F_f - F_p = ma$

$F = \mu mg\cos\theta + mg\sin\theta + ma$

$F = (.295)(2.25)(9.8)\cos 29.7°$

$+(2.25)(9.8)\sin 29.7° + (2.25)(1.52)$

$F = 20.0$ N

P8. $U + K = U + K$

$mgh + .5mv_1^2 = 0 + .5mv_2^2$

$9.8(64.6) + .5v_1^2 = .5(36.4)^2$

$v_1 = 7.67$ m/s

P9. $\sum \tau = 0$

$r_1F_1\sin\theta_1 = r_2F_2\sin\theta_2$

$+r_3F_3\sin\theta_3$

$(.8)F = (1)10(9.8) +$

$2.45(50)9.8$

$F_2 = 1623.13$

$\sum F = 0$

$F_u = F_d$

$F_u = mg + F_2$

$F_u = 60(9.8) + 1623.13$

$F_u = 2210$ N

P10. $\beta = 10\log\dfrac{I}{10^{-12}}$

$84.7 = 10\log\dfrac{I}{10^{-12}}$

$I = 2.9512x10^{-4}$

$Ir^2 = I_2r_2^2$

$\left(2.9512x10^{-4}\right)(50)^2 =$

$I_2(40)^2$

$I_2 = 4.6112x10^{-4}$

$B = 10\log\dfrac{4.6112x10^{-4}}{10^{-12}}$

$B = 86.6$ dB

P11. $W = nRT\ln\left(\dfrac{V_2}{V_1}\right)$

$W = 4(8.314)(308)\ln\left(\dfrac{.336}{.124}\right)$

$W = -10,200$

$\Delta U = Q + W$

$0 = Q - 10,200$

$Q = 10,200$ J

P12. $\dfrac{1}{C} = \dfrac{1}{C_1} + \dfrac{1}{C_2} + \dfrac{1}{C_3}$

$\dfrac{1}{C} = \dfrac{1}{246} + \dfrac{1}{432} + \dfrac{1}{678}$

$C = 127$ nF

P13. $E = \dfrac{kQ}{r^2}$

$\dfrac{k(14.5)}{d^2} = \dfrac{k(22.3)}{(2.95-d)^2}$

$d = 1.316886$

$x = -1.33 + d = -.0131$ m

$$\tau = NIAB\sin\theta$$

P14. $\tau = 100(2.88)\pi(.0652)^2(1)$

$\tau = 1.37\ \text{N}\cdot\text{m}$

$$\xi = NBA\omega\sin(\omega t)$$

$$\xi_0 = NBA\omega$$

P15. $\dfrac{120(2\pi)}{60} = 4\pi$

$\xi_0 = (200)(.853)(.045)(4\pi)$

$\xi_0 = 96.5\ \text{V}$

$$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}$$

$$\frac{1}{-24} = \frac{1}{32} + \frac{1}{d_i}$$

P16. $d_i = -13.7$

$$M = -\frac{d_i}{d_o}$$

$$M = -\frac{-13.7}{32} = .429$$

$$T = T_p\sqrt{1-\frac{v^2}{c^2}}$$

P17. $T = (36)\sqrt{1-(.925)^2}$

$T = 31.7\ \text{yr}$

$$E = \left(.192x10^{6}\right)\left(1.602x10^{-19}\right)$$

$$E = 3.07584x10^{-14}$$

P18. $E = \dfrac{hc}{\lambda},\ \lambda = \dfrac{hc}{E}$

$$\lambda = \frac{\left(6.626x10^{-34}\right)\left(3x10^{8}\right)}{3.07584x10^{-14}}$$

$\lambda = 6.46x10^{-12}\ \text{m}$

$$p = mv$$

$$v = \frac{p}{m}$$

$$K = .5mv^2$$

P19. $K = .5m\left(\dfrac{p}{m}\right)^2$

$$K = \frac{p^2}{2m}$$

$$K = \frac{(9.56)^2}{2(.425)}$$

$K = 108\ \text{J}$

$$\sum F = ma$$

$$F_E = EQ$$

$$EQ = ma$$

P20. $a = \dfrac{EQ}{m}$

$$a = \frac{6000\left(9.66x10^{-9}\right)}{5.62x10^{-5}}$$

$a = 1.03\ \text{m/s}^2$