ABBREVIATIONS AND SYMBOLS						
amount of substance	n	equilibrium constant	K	milli- prefix	m	
ampere	A	Faraday constant	F	molal	m	
atmosphere	atm	formula molar mass	M	molar	M	
atomic mass unit	u	free energy	G	mole	mol	
atomic molar mass	\boldsymbol{A}	frequency		Planck's constant	h	
Avogadro constant	$N_{\mathbf{A}}$	gas constant	R	pressure	P	
Celsius temperature	°C	gram	g	rate constant	k	
centi- prefix	c	hour	h	second	S	
coulomb	C	joule	J	speed of light	c	
electromotive force	E	kelvin	K	temperature, K	T	
energy of activation	E_{a}	kilo- prefix	k	time	t	
enthalpy	H	liter	L	volt	V	
entropy	S	measure of pressure m	ımHg	volume	V	

CONSTANTS
$R = 8.314 \text{ J} \cdot \text{mol}^{-1} \cdot \text{K}^{-1}$ $R = 0.0821 \text{ L} \cdot \text{atm} \cdot \text{mol}^{-1} \cdot \text{K}^{-1}$ $1 F = 96,500 \text{ C} \cdot \text{mol}^{-1}$ $1 F = 96,500 \text{ J} \cdot \text{V}^{-1} \cdot \text{mol}^{-1}$
$N_{\rm A} = 6.022 \times 10^{23} \rm mol^{-1}$
$h = 6.626 \times 10^{-34} \text{ J} \cdot \text{s}$
$c = 2.998 \times 10^8 \text{ m} \cdot \text{s}^{-1}$

PERIODIC TABLE OF THE ELEMENTS

$\begin{array}{c c} 1 \\ \mathbf{H} \end{array}$																	2 He
1.008											_						4.003
3	4											5	6	7	8	9	10
Li 6.941	Be 9.012											B 10.81	C 12.01	N 14.01	O 16.00	F 19.00	Ne 20.18
11	12											13	14	15	16	17	18
Na 22.99	Mg 24.31											Al 26.98	Si 28.09	P 30.97	S 32.07	Cl 35.45	Ar 39.95
19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
K 39.10	Ca 40.08	Sc 44.96	Ti 47.88	V 50.94	Cr 52.00	Mn 54.94	Fe 55.85	Co 58.93	Ni 58.69	Cu 63.55	Zn 65.39	Ga 69.72	Ge 72.61	As 74.92	S e 78.96	Br 79.90	Kr 83.80
37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
Rb 85.47	Sr 87.62	Y 88.91	Zr 91.22	Nb 92.91	Mo 95.94	Tc (98)	Ru 101.1	Rh 102.9	Pd 106.4	Ag 107.9	Cd 112.4	In 114.8	Sn 118.7	Sb 121.8	Te 127.6	I 126.9	Xe 131.3
55	56	57	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86
Cs 132.9	Ba 137.3	La 138.9	Hf 178.5	Ta 181.0	W 183.8	Re 186.2	Os 190.2	Ir 192.2	Pt 195.1	Au 197.0	Hg 200.6	Tl 204.4	Pb 207.2	Bi 209.0	Po (209)	At (210)	Rn (222)
87	88	89	104	105	106	107	108	109	110	111	112		114				
Fr (223)	Ra 226.0	Ac 227.0	Rf (261)	Db (262)	Sg (263)	Bh (262)	Hs (265)	Mt (266)	(269)	(272)	(277)		(289)				
												-				_	
		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	91	92	93	94	95	96	97	98	99	100		102			
		Th 232.0	Pa 231.0	U 238.0	Np 237.0	Pu (244)	Am (243)	Cm (247)	Bk (247)	Cf (251)	Es (252)	Fm (257)	Md (258)	No (259)	(260)		

DIRECTIONS

- When you have selected your answer, blacken the corresponding space on the answer sheet with a soft, black #2 pencil. Make a heavy, full mark, but no stray marks. If you decide to change an answer, erase the unwanted mark very carefully.
- Make no marks in the test booklet. Do all calculations on scratch paper provided by your examiner.
- There is only one correct answer to each question. Any questions for which more than one response has been blackened will not be counted.
- Your score is based solely on the number of questions you answer correctly. It is to your advantage to answer every question.
- The best strategy is to arrive at your own answer to a question before looking at the choices. Otherwise, you may be misled by plausible, but incorrect, responses.
 - **1.** Which element reacts most rapidly with water at 25 °C to produce a gas?
 - (A) aluminum
- (B) carbon
- (C) lithium
- (D) phosphorus
- **2.** Which is the best procedure to follow if a student spills several drops of concentrated HCl on his hand?
 - (A) Cover the area with solid sodium hydrogen carbonate.
 - (B) Rinse with large amounts of cold water.
 - (C) Wash with concentrated sodium hydroxide solution.
 - (**D**) Wrap the hand with sterile gauze.
- **3.** Which pair of substances can be combined to produce ammonia gas?
 - 1. $(NH_4)_2SO_4(s)$ and NaOH(aq)
 - **2**. $NH_3(aq)$ and HCl(aq)
 - (A) 1 only
- **(B)** 2 only
- (C) both 1 and 2
- (D) neither 1 nor 2
- **4.** What products result when equal volumes of equimolar aqueous solutions of copper(II) sulfate and barium hydroxide are mixed?
 - (A) $Ba^{2+}(aq)$, $Cu^{2+}(aq)$, $OH^{-}(aq)$, and $SO_4^{2-}(aq)$
 - **(B)** Cu(OH)(s), Ba²⁺(aq), and SO₄²⁻(aq)
 - (C) BaSO₄(s), Cu²⁺(aq), and OH⁻(aq)
 - **(D)** BaSO₄(s) and Cu(OH)₂(s)
- **5.** Which statement about silicon is *false*?
 - (A) It is a metalloid.
 - **(B)** It behaves as a semiconductor when pure.
 - (C) It is extremely rare in the earth's crust.
 - (**D**) It has a smaller atomic radius than aluminum.

- **6.** A standard HCl solution is titrated to a pink phenolphthalein endpoint by adding a NaOH solution while stirring. If a solution becomes pink throughout but loses its color upon standing for a short time, what should be done to restore the color?
 - (A) Add more phenolphthalein indicator.
 - (B) Add an additional drop of NaOH solution.
 - (C) Add an additional drop of HCl solution.
 - **(D)** Stir more vigorously.
- 7. A sample of gas in a small test tube produces a pop when a burning splint is inserted. Which gas could it be?
 - (A) H_2
- **(B)** O_2
- (C) Cl₂
- **(D)** NO
- **8.** Electrolysis is used commercially to isolate which metal(s)?
 - **1.** Al
- **2.** Fe
- (A) 1 only
- **(B)** 2 only
- (C) both 1 and 2
- (D) neither 1 nor 2
- **9.** An oxide of manganese contains 2.29 g of manganese per gram of oxygen. What is the empirical formula of this compound?
 - (A) MnO
- (**B**) MnO_2
- (C) Mn_2O_3
- **(D)** MnO_3
- **10.** A heterogeneous system is produced when 0.040 moles of solid NaCl is added to 0.10 L of 0.10 M Pb(NO₃)₂. Which ion is present in the aqueous phase at the highest concentration?
 - (A) Cl⁻

- $(\mathbf{B}) \ \mathrm{NO}_3^-$
- (C) Pb^{2+}
- **(D)** Na⁺
- **11.** Which expression gives the fraction by mass of nitrogen in ammonium dihydrogen phosphate?
 - **(A)** 14 / 115
- **(B)** 28 / 115
- **(C)** 28 / 132
- **(D)** 14 / 210

12. Ethanol burns in excess oxygen to form $CO_2(g)$ and $H_2O(g)$ according to this balanced equation.

$$C_2H_5OH(g) + 3O_2(g)$$
 $2CO_2(g) + 3H_2O(g)$

What value is closest to the volume of $CO_2(g)$, measured at 200K and 1 atm, produced from the combustion of 0.25 mol of $C_2H_5OH(g)$?

(A) 5 L

(B) 8 L

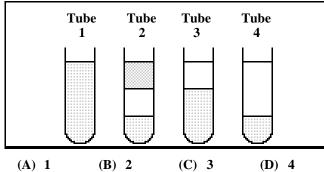
(C) 10 L

- **(D)** 15 L
- **13.** Adipic acid, HOOC(CH₂)₄COOH, is used in making nylon. What is the total number of atoms in 1.0 g of adipic acid?

Molar Mass	, g·mol⁻¹
adipic acid	146.26

(A) 20

- **(B)** 4.1×10^{21}
- (C) 8.2×10^{22}
- **(D)** 7.2×10^{24}
- **14.** Hexane, C₆H₁₄, is immiscible with water and ethanol. Water and ethanol are miscible. C₆H₁₄ has the lowest density. Which diagram represents the results when equal volumes of these three liquids are placed in a test tube and shaken?

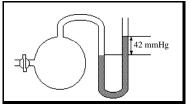


15. $5H_2C_2O_4(aq) + 2MnO_4^-(aq) + 6H^+(aq)$ $2Mn^{2+}(aq) + 10CO_2(g) + 8H_2O(l)$

Oxalic acid, $H_2C_2O_4$, reacts with permanganate ion according to the balanced equation above. How many mL of 0.0154 M KMnO₄ solution are required to react with 25.0 mL of 0.0208 M $H_2C_2O_4$ solution?

- (**A**) 13.5 mL
- **(B)** 18.5 mL
- (C) 33.8 mL
- **(D)** 84.4 mL
- **16.** A sample of neon gas has a volume of 248 mL at 30.°C and a certain pressure. What volume would it occupy if it were heated to 60.°C at the same pressure?
 - (A) 226 mL
- **(B)** 273 mL
- (C) 278 mL
- **(D)** 496 mL

17. A gas is collected in the flask shown here. What is the pressure exerted by the gas if the atmospheric pressure is 735 mmHg?



- (A) 42 mmHg
- (**C**) 735 mmHg
- (B) 693 mmHg(D) 777 mmHg
- **18.** Helium is often found with methane, CH₄. How do the diffusion rates of helium and methane compare at the same temperature? Helium diffuses
 - (A) sixteen times as fast as methane.
 - **(B)** four times as fast as methane.
 - (C) twice as fast as methane.
 - **(D)** at the same rate as methane.
- **19.** Which substance contains individual molecules in the solid?
 - (A) graphite
- (B) iodine
- (C) mercury
- (**D**) silicon carbide
- **20.** The compounds C₃H₈, CH₃CH₂OH, and CH₃OCH₃ have very similar molar masses. When they are arranged in order of *increasing* strength of their intermolecular forces, what is the correct order?
 - (A) C₃H₈, CH₃OCH₃, CH₃CH₂OH
 - (B) CH₃CH₂OH, CH₃OCH₃, C₃H₈
 - (C) CH₃OCH₃, C₃H₈, CH₃CH₂OH
 - (**D**) CH₃CH₂OH, C₃H₈, CH₃OCH₃
- 21. Which property does *not* indicate strong intermolecular forces?
 - (A) high enthalpy of vaporization
 - (B) high viscosity
 - (C) high critical temperature
 - **(D)** high vapor pressure
- 22. Calculate the amount of energy necessary to heat a 2.5 g ice cube from 0 °C to 23 °C.

	Values for H ₂ O					
)	$C_{\rm p}$	$4.18 \text{ J} \cdot \text{g}^{-1} \cdot {}^{\circ}\text{C}^{-1}$				
	$H_{\it fusion}$	$3.4\times10^2~J{\cdot}g^{-1}$				

- (**A**) 240 J
- **(B)** 850 J
- (**C**) 1100 J
- **(D)** 3700 J

23. Estimate H for this reaction.

$H_2(g) + Cl_2(g) \qquad 2H$

Bond Energies, kJ·mol ⁻¹				
436				
243				
431				

- (A) 1110 kJ
- **(B)** 248 kJ
- (C) -183 kJ
- **(D)** -248 kJ
- **24.** Which reaction occurs with an increase in entropy?

(A)
$$2C(s) + O_2(g)$$
 $2CO(g)$

(B)
$$2H_2S(g) + SO_2(g)$$
 $3S(s) + 2H_2O(g)$

(C)
$$4\text{Fe}(s) + 3\text{O}_2(g)$$
 $2\text{Fe}_2\text{O}_3(s)$

(D)
$$CO(g) + 2H_2(g)$$
 $CH_3OH(l)$

25. Consider this reaction.

$$2N_2H_4(l) + N_2O_4(l)$$
 $3N_2(g) + 4H_2O(g)$ $H = -1078$ kJ How much energy is released by this reaction during the formation of 140. g of $N_2(g)$?

- (**A**) 1078 kJ
- **(B)** 1797 kJ
- (C) 3234 kJ
- **(D)** 5390 kJ
- **26.** Use the information in the table to calculate the enthalpy of this reaction.

$$C_2H_6(g) + 7/2O_2(g)$$
 $2CO_2(g) + 3H_2O(l)$

Reaction	$H_f^{ m o}$, kJ·mol $^{-1}$
$ \begin{array}{cccc} 2C(s) + 3H_2(g) & C_2H_6(g) \\ 2C(s) + O_2(g) & CO_2(g) \\ H_2(g) + 1/2O_2(g) & H_2O(l) \end{array} $	-84.7 -393.5 -285.8

- **(A)** -764 kJ
- **(B)** -1560 kJ
- (C) -1664 kJ
- **(D)** -3120 kJ
- **27.** For the reaction $PCl_3(g) + Cl_2(g)$ $PCl_5(g)$, $H^0 = -86$ kJ. Under what temperatures is this reaction expected to be spontaneous?
 - (A) no temperatures
- **(B)** high temperatures only
- (C) all temperatures
- (D) low temperatures only
- **28.** The radioisotope, N-13, has a half-life of 10.0 minutes. What is the rate constant for the radioactive decay of N-13?
 - (A) 0.0301 min^{-1}
- **(B)** 0.0693 min^{-1}
- (C) $0.100 \, \text{min}^{-1}$
- **(D)** 6.93 min^{-1}

- **29.** For the reaction $2C_2H_6(g) + 7O_2(g)$ $4CO_2(g) + 6H_2O(l)$, the rate of disappearance of $C_2H_6(g)$
 - (A) equals the rate of disappearance of $O_2(g)$.
 - **(B)** is seven times the rate of disappearance of $O_2(g)$.
 - (C) is twice the rate of appearance of $CO_2(g)$.
 - **(D)** is one-third the rate of appearance of $H_2O(l)$.
- **30.** The rate law for a certain reaction is found to be:

rate =
$$k [A] [B]^2$$

How will the rate of this reaction compare if the concentration of $\bf A$ is doubled and the concentration of $\bf B$ is halved? The rate will

- (A) remain the same.
- **(B)** be double the original rate.
- (C) be triple the original rate.
- **(D)** be one-half the original rate.
- **31.** Use the experimental data in this table to determine the rate law for the reaction of hydrogen iodide, HI, with ethyl iodide, C_3H_5I .

[HI], M	$[C_2H_5I], M$	Rate, M·s ⁻¹
0.010 0.010	0.010 0.020	1.2×10^{-5} 2.4×10^{-5}
0.010	0.020	7.2×10^{-5}

- (A) rate = k [HI]
- **(B)** rate = k [HI] [C₂H₅I]
- (C) rate = $k \text{ [HI]}^2 \text{ [C}_2 \text{H}_5 \text{I]}$
- **(D)** rate = $k [HI]^2 [C_2H_5I]^3$
- **32.** For the reaction $NO_2(g) + CO(g) = NO(g) + CO_2(g)$ at temperatures below 500 K, the rate law is rate = $k [NO_2]^2$. Which mechanism is consistent with this information?

Mechanism 1
$$NO_2 + NO_2$$
 $NO_3 + NO$ slow

$$CO + NO_3 \qquad CO_2 + NO_2 \qquad fast$$

Mechanism 2
$$NO_2 + NO_2 \rightleftharpoons NO_3 + NO$$
 fast

$$CO + NO_3 \quad CO_2 + NO_2 \quad slow$$

- **(A) 1** only
- **(B)** 2 only
- (C) either 1 or 2
- (D) neither 1 nor 2

33. Mercury(II) oxide, HgO, is decomposed upon heating according to this equation.

$$2\text{HgO}(s) \rightleftharpoons 2\text{Hg}(l) + \text{O}_2(g)$$

What is the equilibrium expression for this process?

(A)
$$K = \frac{[Hg]^2 [O_2]}{[HgO]^2}$$

$$(\mathbf{B}) \quad K = \frac{[\mathrm{Hg}][\mathrm{O}_2]}{[\mathrm{HgO}]}$$

(C)
$$K = [Hg][O_2]$$

$$(\mathbf{D}) \quad K = [\mathbf{O}_2]$$

34. Consider this reaction.

$$2NO(g) + Cl_2(g) \rightleftharpoons 2NOCl(g)$$

$$H = -78.38 \text{ kJ}$$

What conditions of temperature and pressure will produce the highest yield of NOCl at equilibrium?

_	T	P
(A)	high	high
(B)	high	low
(C)	low	high
(D)	low	low

35. The dihydrogen phosphate ion undergoes these reactions in water.

$$H_2PO_4^-(aq) + H_2O(l) \rightleftharpoons HPO_4^{2-}(aq) + H_3O^+(aq) K = 6.2 \times 10^{-8}$$

$$H_2PO_4^-(aq) + H_2O(l) \rightleftharpoons H_3PO_4(aq) + OH^-(aq) \quad K = 1.6 \times 10^{-7}$$

What is the conjugate base of $H_2PO_4^{-}$?

- (A) $HPO_4^{2-}(aq)$
- **(B)** $H_2O(l)$
- (C) $OH^-(aq)$
- (**D**) $H_3PO_4(aq)$
- **36.** What is the pH of a 0.15 M solution of formic acid, HCOOH?

Formic Acid	K_A	
НСООН	1.9×10^{-4}	

(A) 1.49

(B) 2.27

(C) 3.72

- **(D)** 4.55
- **37.** Which of these mixtures constitute buffer solutions?

Mixture 1 25 mL of 0.10 M HNO₃ and 25 mL of 0.10 M NaNO₃

Mixture 2 25 mL of 0.10 M HC₂H₃O₂ and 25 mL of 0.10 M NaOH

- (**A**) **1** only
- **(B)** 2 only
- (C) both 1 and 2
- (D) neither 1 nor 2

- **38.** Which salt gives the most acidic 0.1 M solution in water?
 - (A) NaCl
- (B) NaNO₂
- (C) NH₄Cl
- **(D)** NH_4NO_2
- **39.** What is the solubility of magnesium carbonate, MgCO₃, in water at 25 °C?

Data for MgCO ₃				
molar mass	84 g⋅mol ⁻¹			
$K_{\rm sp}$ at 25 °C	6.8×10^{-6}			

- (A) $0.22 \text{ g} \cdot \text{L}^{-1}$
- **(B)** $2.6 \times 10^{-3} \text{ g} \cdot \text{L}^{-1}$
- (C) $3.1 \times 10^{-5} \text{ g} \cdot \text{L}^{-1}$
- **(D)** $8.1 \times 10^{-8} \text{ g} \cdot \text{L}^{-1}$
- **40.** For which substance is the oxidation number of vanadium the same as that in the VO₃⁻ ion?
 - (A) VN

- **(B)** VCl_3
- (C) VOSO₄
- **(D)** VF₅
- **41.** $_ClO_3^- + _I^- + _H^+ \quad _Cl^- + _I_2 + _H_2O$

When this equation is balanced with whole number coefficients, what is the H⁺/I₂ coefficient ratio?

(A) 2/1

(B) 3/1

(C) 6/1

- (**D**) some other ratio
- **42.** Use the information in the table to calculate E° for this reaction.

$Ga(s) + 3Tl^+(aq)$	$3\text{Tl}(s) + \text{Ga}^{3+}(aq)$
Reaction	E°
$Ga^{3+}(aq) + 3e^- Ga(s)$	-0.529 V
$Tl^+(aq) + e^- \qquad Tl(s)$	–0.336 V

- (A) 0.479 V
- **(B)** 0.193 V
- (C) -0.193 V
- **(D)** -0.479 V
- **43.** Nickel metal is added to a solution containing 1.0 M Pb²⁺(aq) and 1.0 M Cd²⁺(aq). Use the standard reduction potentials to determine which reaction(s) will occur. Reaction 1. Ni(s) + Pb²⁺(aq). Ph(s) + Ni²⁺(aq)

Reaction 1 Ni(s) + Pb²⁺(aq) Pb(s) + Ni²⁺(aq) Reaction 2 Ni(s) + Cd²⁺(aq) Cd(s) + Ni²⁺(aq)

Reaction	E°
$Pb^{2+}(aq) + 2e^{-} Pb(s)$	-0.13 V
$Ni^{2+}(aq) + 2e^{-}$ $Ni(s)$	–0.23 V
$\operatorname{Cd}^{2+}(aq) + 2e^{-} \operatorname{Cd}(s)$	–0.40 V

- (**A**) **1** only
- **(B)** 2 only
- (C) both 1 and 2
- (D) neither 1 nor 2

$ (C) \mid \mathbf{S} \times \mathbf{S} \times \mathbf{C} \times \mathbf{N} \times \mathbf{S} = (D) \mid \mathbf{S} \times \mathbf{S} \times \mathbf{C} \times \mathbf{S} $	N •]			FNDO	FTES	T	
		(C)	N and	P	(D)	N and S	
·	·] -			•		P	
Which Lewis dot structure is the best representathe bonding in the thiocyanate ion, SCN ⁻ ?	ation of 60.					d oxygen, what e	else is
(C) Co and Cu (D) F and I		(C)	2 sigm	a and 3 pi	(D)	3 sigma and 2 p	i
			_		` ′		
the most similar?				_			
Which pair of elements have chemical propertie	es that are	(A)	2	(B) 3	(C)	4 (D) :)
(A) F (B) Ne (C) Na (D	58. Mg		-				
Which has the highest ionization energy for the of the <i>second</i> electron?		, ,		· ·			
(C) 3d4s4p (D) 4p4d4f	31.	prop	pene?				o
(A) 3s3p3d (B) 3p4s3d	57	Нол	v manv	hvdrogen ator	ns are in	one molecule of	
sequential order of filling subshells in a ground atom?	state	(C)	ester		(D)	ketone	
According to the Aufbau principle, which is the		(A)	aldehy	de	(B)	alkene	
		Wh	at is the	oxidation pro	duct of a	primary alcohol?	?
	•	(0)	~rJ.		(-)		
			•				
		desc	cribed as	3			
(A) 13 (B) 14 (C) 15 (D	55 .						
How many orbitals contain one or more electronisolated ground state iron atom $(Z = 26)$?	ns in an	(C)	both 1	and 2	(D)	neither 1 nor 2	
		(A)	1 only		(B)	2 only	
	•	2001		-			
	54.					hich species do a	ll the
more unpaired electrons?		(C)	SIF ₄		(D)	CIF ₄	
Coccess stoms of which of these elements cont	oin one on		•				
(D) cathode and undergoes oxidation.	231	rule	?			•	
(C) cathode and undergoes reduction.	53.	Inv	hich sp	ecies does the	central a	itom obey the oct	tet
(B) anode and undergoes oxidation.		(C)	AI and	Se	(D)	Al and O	
					` ′		
What happens to a cation during the electrolysis of a		Wh	ich pair	of atoms form	s the mo	st ionic bond?	
	molten salt? The cation moves toward the (A) anode and undergoes reduction. (B) anode and undergoes oxidation. (C) cathode and undergoes reduction. (D) cathode and undergoes oxidation. Gaseous atoms of which of these elements contimore unpaired electrons? Ge (Z = 32) As (Z = 33) Se (Z = 34) As only (B) Ge and As only (C) Ge and Se only (D) Ge, As, and How many orbitals contain one or more electronisolated ground state iron atom (Z = 26)? (A) 13 (B) 14 (C) 15 (D) Which property decreases from left to right acreperiodic table and increases from top to bottom (A) atomic radius (B) electronegate (C) ionization energy (D) melting point acreperiodic table and increases from top to bottom (A) atomic radius (B) electronegate (C) ionization energy (D) melting point atom? (A) 3s3p3d (B) 3p4s3d (C) 3d4s4p (D) 4p4d4f Which has the highest ionization energy for the of the second electron? (A) F (B) Ne (C) Na (D) F and I Which Lewis dot structure is the best representation the most similar? (A) Be and B (B) Al and Ga (C) Co and Cu (D) F and I	molten salt? The cation moves toward the (A) anode and undergoes reduction. (B) anode and undergoes oxidation. (C) cathode and undergoes oxidation. (D) cathode and undergoes oxidation. (E) cathode and undergoes oxidation. (D) cathode and undergoes oxidation. (E) cathode and undergoes oxidation. (G) cathode and undergoes oxidation. (E) cathode and undergoes oxidation. (A) As only (B) Ge and As only (C) Ge and Se only (D) Ge, As, and Se (A) 13 (B) 14 (C) 15 (D) 16 (A) 13 (B) 14 (C) 15 (D) 16 (A) atomic radius (B) electrons the periodic table and increases from top to bottom? (A) atomic radius (B) electronegativity (C) ionization energy (D) melting point (C) ionization energy (D) melting point (A) 3s3p3d (B) 3p4s3d (C) 3d4s4p (D) 4p4d4f (C) 3d4s4p (D) 4p4d4f (D) 4p4d4f (D) 4p4d4f (E) Ne (C) Na (D) Mg (E) Ne (C) Na (D) Mg (E) Se (C) Na (D) Mg (E) Se (C) Na (D) Mg (E) Se (C) Na (D) Fand I	molten salt? The cation moves toward the (A) anode and undergoes reduction. (B) anode and undergoes oxidation. (C) cathode and undergoes oxidation. (D) cathode and undergoes oxidation. (E) cathode and undergoes oxidation. (D) cathode and undergoes oxidation. (A) Gaseous atoms of which of these elements contain one or more unpaired electrons? Ge (Z = 32) As (Z = 33) Se (Z = 34) (A) As only (B) Ge and As only (C) Ge and Se only (D) Ge, As, and Se (A) How many orbitals contain one or more electrons in an isolated ground state iron atom (Z = 26)? (A) 13 (B) 14 (C) 15 (D) 16 Which property decreases from left to right across the periodic table and increases from top to bottom? (A) atomic radius (B) electronegativity (C) ionization energy (D) melting point 56. Wh. According to the Aufbau principle, which is the sequential order of filling subshells in a ground state atom? (A) 3s3p3d (B) 3p4s3d (C) 3d4s4p (D) 4p4d4f Which has the highest ionization energy for the removal of the second electron? (A) F (B) Ne (C) Na (D) Mg Which pair of elements have chemical properties that are the most similar? (A) Be and B (B) Al and Ga (A) (C) Co and Cu (D) F and I (C) Which Lewis dot structure is the best representation of the bonding in the thiocyanate ion, SCN-? (A) [\$\frac{1}{2}\$\$\$\frac{1}{2}\$\$\$\$\frac{1}{2}\$\$\$\frac{1}{2}\$	molten salt? The cation moves toward the (A) anode and undergoes reduction. (B) anode and undergoes oxidation. (C) cathode and undergoes oxidation. (C) cathode and undergoes oxidation. (C) cathode and undergoes oxidation. (D) cathode and undergoes oxidation. (E) cathode and undergoes oxidation. (C) cathode and undergoes oxidation. (C) cathode and undergoes oxidation. (E) cathode and undergoes oxidation. (C) cathode and undergoes oxidation. (A) XeF ₄ (C) SiF ₄ (A) As only (B) Ge and As only (C) Ge and Se only (D) Ge, As, and Se (A) 1 only (C) both 1 isolated ground state iron atom (Z = 26)? (A) 13 (B) 14 (C) 15 (D) 16 (A) 10 only (C) both 1 isolated ground state iron atom (Z = 26)? (A) atomic radius (B) electronegativity (C) ionization energy (D) melting point (C) sp ² byth (C) ionization energy (D) melting point (C) syp ² byth (D) syp ² byth (D	molten salt? The cation moves toward the (A) anode and undergoes reduction. (B) anode and undergoes reduction. (C) cathode and undergoes oxidation. (C) cathode and undergoes oxidation. (C) cathode and undergoes oxidation. (G) cathode and undergoes reduction. (G) cathode and undergoes reduction. (G) cathode and undergoes oxidation. (G) cathode and undergoes oxidation. (G) cathode and undergoes oxidation. (A) XeF4 (C) SiF4 According to VSEPR theatoms lie in the same plant 1. CH ₃ * (A) 1 only (C) both 1 and 2 (C) both 1 and 2 (D) both 1 and 2 (E) sphrid orbitals. (C) sphybrid orbitals. (C) seter 56. What is the oxidation pro (A) aldehyde (C) ester 57. How many hydrogen ator propence? (A) 3 (B) 4 58. How many different compropence? (A) 3 (B) 4 59. What bonds are present in (A) 5 sigma (C) 2 sigma and 3 pi (D) In addition to carbon, hydround in every amino acide (A) N (C) N and P	molten salt? The cation moves toward the (A) anode and undergoes reduction. (B) anode and undergoes oxidation. (C) cathode and undergoes oxidation. (D) cathode and undergoes oxidation. Gascous atoms of which of these elements contain one or more unpaired electrons? Ge (Z = 32) As (Z = 33) Se (Z = 34) (A) As only (B) Ge and As only (C) Ge and Se only (D) Ge, As, and Se How many orbitals contain one or more electrons in an isolated ground state iron atom (Z = 26)? (A) 13 (B) 14 (C) 15 (D) 16 Which property decreases from left to right across the periodic table and increases from top to bottom? (A) atomic radius (B) electronegativity (C) ionization energy (D) melting point According to the Aufbau principle, which is the sequential order of filling subshells in a ground state atom? (A) 333p3d (B) 3p4x3d (C) 3d4s4p (D) 4p4d4f Which has the highest ionization energy for the removal of the second electron? (A) F (B) Ne (C) Na (D) Mg Which pair of elements have chemical properties that are the most similar? (A) Be and B (B) Al and Ga (C) Co and Cu (D) F and I Which Lewis dot structure is the best representation of the bonding in the thiocyanate ion, SCN*? (A) Al and As (B) (C) Al and Se (D) Al mwhich species does the central rule? (A) XeF4 (B) (C) SiF4 (D) According to VSEPR theory, in warrows in the same plane? 1. CH3* 2. CH3* (A) 1 only (B) (C) both 1 and 2 (D) 55. The H—O—H bond angles in H,O* a 107°. The orbitals used by oxygen described as (A) p orbitals. (B) (C) sp² hybrid orbitals. (D) 56. What is the oxidation product of a (A) aldehyde (B) (C) ester (D) 57. How many hydrogen atoms are in propenc? (A) 2 (B) 3 (C) Which pair of elements have chemical properties that are the most similar? (A) Be and B (B) Al and Ga (C) C and Cu (D) F and I Which Lewis dot structure is the best representation of the bonding in the thiocyanate ion, SCN*? (A) N (B) (C) N (D) N (D) (D) N (D) N (D) N (D) N (D) (E) Al and As (D) (D) Al and B (C) SiF4 (D) (E) SiF4 (D) (C) SiF4 (D) (A) A ccording t	molten sair? The cation moves toward the (A) and and and undergoes reduction. (B) anode and undergoes oxidation. (C) cathode and undergoes coxidation. (D) cathode and undergoes coxidation. (D) cathode and undergoes coxidation. (E) Gaseous atoms of which of these elements contain one or more unpaired electrons? Ge (Z = 32) As (Z = 33) Se (Z = 34) (A) As only (B) Gc and As only (C) Ge and Se only (D) Ge, As, and Se (A) A sonly (B) Gc and As only (C) Ge and Se only (D) Ge, As, and Se (C) SiF ₄ (D) CIF ₂ (C) SiF ₄ (D) CIF ₂ (A) 1 only (B) 2 only (C) both 1 and 2 (D) neither 1 nor 2 is in the same plane? (A) 1 only (B) 2 only (C) both 1 and 2 (D) neither 1 nor 2 is in the same plane? (A) 1 only (B) 2 only (C) both 1 and 2 (D) neither 1 nor 2 is sequential order of filling subshells in a ground state atom? (A) 3 a3p3d (B) sphybrid orbitals. (B) sphybrid orbitals. (C) sp² hybrid orbitals. (D)

U.S. NATIONAL CHEMISTRY OLYMPIAD 2002 LOCAL SECTION EXAM — KEY

Number	Answer	Number	Answer	Number	Answer
1.	C	21.	D	41.	A
2.	В	22.	C	42.	В
3.	\mathbf{A}	23.	C	43.	\mathbf{A}
4.	D	24.	\mathbf{A}	44.	C
5.	C	25.	В	45.	D
6.	В	26.	В	46.	C
7.	\mathbf{A}	27.	D	47.	\mathbf{A}
8.	\mathbf{A}	28.	В	48.	В
9.	C	29.	D	49.	C
10.	D	30.	D	50.	В
11.	\mathbf{A}	31.	В	51.	D
12.	В	32.	\mathbf{A}	52.	D
13.	C	33.	D	53.	C
14.	C	34.	C	54.	\mathbf{A}
15.	\mathbf{A}	35.	\mathbf{A}	55.	D
16.	В	36.	В	56.	\mathbf{A}
17.	D	37.	D	57.	\mathbf{C}
18.	C	38.	C	58.	В
19.	В	39.	\mathbf{A}	59.	D
20.	\mathbf{A}	40.	D	60.	\mathbf{A}

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