M09/4/CHEMI/HPM/ENG/TZ2/XX+

22096113

CHEMISTRY
HIGHER LEVEL
PAPER 1

Monday 18 May 2009 (afternoon)

1 hour

INSTRUCTIONS TO CANDIDATES

- Do not open this examination paper until instructed to do so.
- Answer all the questions.
- For each question, choose the answer you consider to be the best and indicate your choice on the answer sheet provided.
- The periodic table is provided for reference on page 2 of this examination paper.

The Periodic Table

Atomic Number **Element** Atomic Mass

1	2											3	4	5	6	7	0
1 **H** 1.01																	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											13 **Al** 26.98	14 **Si** 28.09	15 **P** 30.97	16 **S** 32.06	17 **Cl** 35.45	18 **Ar** 39.95
19 **K** 39.10	20 **Ca** 40.08	21 **Sc** 44.96	22 **Ti** 47.90	23 **V** 50.94	24 **Cr** 52.00	25 **Mn** 54.94	26 **Fe** 55.85	27 **Co** 58.93	28 **Ni** 58.71	29 **Cu** 63.55	30 **Zn** 65.37	31 **Ga** 69.72	32 **Ge** 72.59	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** 98.91	44 **Ru** 101.07	45 **Rh** 102.91	46 **Pd** 106.42	47 **Ag** 107.87	48 **Cd** 112.40	49 **In** 114.82	50 **Sn** 118.69	51 **Sb** 121.75	52 **Te** 127.60	53 **I** 126.90	54 **Xe** 131.30
55 **Cs** 132.91	56 **Ba** 137.34	57 † **La** 138.91	72 **Hf** 178.49	73 **Ta** 180.95	74 **W** 183.85	75 **Re** 186.21	76 **Os** 190.21	77 **Ir** 192.22	78 **Pt** 195.09	79 **Au** 196.97	80 **Hg** 200.59	81 **Tl** 204.37	82 **Pb** 207.19	83 **Bi** 208.98	84 **Po** (210)	85 **At** (210)	86 **Rn** (222)
87 **Fr** (223)	88 **Ra** (226)	89 ‡ **Ac** (227)															

†	58 **Ce** 140.12	59 **Pr** 140.91	60 **Nd** 144.24	61 **Pm** 146.92	62 **Sm** 150.35	63 **Eu** 151.96	64 **Gd** 157.25	65 **Tb** 158.92	66 **Dy** 162.50	67 **Ho** 164.93	68 **Er** 167.26	69 **Tm** 168.93	70 **Yb** 173.04	71 **Lu** 174.97
‡	90 **Th** 232.04	91 **Pa** 231.04	92 **U** 238.03	93 **Np** (237)	94 **Pu** (242)	95 **Am** (243)	96 **Cm** (247)	97 **Bk** (247)	98 **Cf** (251)	99 **Es** (254)	100 **Fm** (257)	101 **Md** (258)	102 **No** (259)	103 **Lr** (260)

1. What is the number of oxygen atoms in one mole of $CuSO_4 \bullet 5H_2O$?

A. 5

B. 9

C. 6.0×10^{23}

D. 5.4×10^{24}

2. Which sample has the greatest mass?

A. 6.0×10^{25} molecules of hydrogen

B. 5.0 mol of neon atoms

C. 1.2×10^{24} atoms of silver

D. 1.7×10^{2} g of iron

3. What volume of sulfur trioxide, in cm^3, can be prepared using 40 cm^3 sulfur dioxide and 20 cm^3 oxygen gas by the following reaction? Assume all volumes are measured at the same temperature and pressure.

$$2SO_2(g) + O_2(g) \rightarrow 2SO_3(g)$$

A. 20

B. 40

C. 60

D. 80

4. Which sample of nitrogen gas, N_2, contains the greatest number of nitrogen molecules?

A. 1.4 g N_2

B. 1.4 dm^3 of N_2 at 1.01×10^5 Pa and 273 K

C. 1.4×10^{23} N_2 molecules

D. 1.4 mol N_2

5. The table below shows the number of protons, neutrons and electrons present in five species.

Species	Number of protons	Number of neutrons	Number of electrons
X	6	8	6
Y	7	7	7
Z	7	7	8
W	8	8	8
Q	8	10	8

Which **two** species are isotopes of the same element?

A. X and W

B. Y and Z

C. Z and W

D. W and Q

6. What is the order of increasing energy of the orbitals within a single energy level?

A. $d < s < f < p$

B. $s < p < d < f$

C. $p < s < f < d$

D. $f < d < p < s$

7. What is the electron configuration of the Cr^{2+} ion?

A. $[Ar]\ 3d^5\ 4s^1$

B. $[Ar]\ 3d^3\ 4s^1$

C. $[Ar]\ 3d^6\ 4s^1$

D. $[Ar]\ 3d^4\ 4s^0$

8. Which statement describes the trends of electronegativity values in the periodic table?

A. Values increase from left to right across a period and increase down a group.

B. Values increase from left to right across a period and decrease down a group.

C. Values decrease from left to right across a period and increase down a group.

D. Values decrease from left to right across a period and decrease down a group.

9. Which equation best represents the first ionization energy of magnesium?

A. $Mg(s) \rightarrow Mg^{+}(s) + e^{-}$

B. $Mg(g) \rightarrow Mg^{2+}(g) + 2e^{-}$

C. $Mg(g) \rightarrow Mg^{+}(g) + e^{-}$

D. $Mg(s) \rightarrow Mg^{+}(g) + e^{-}$

10. What are the products of the reaction between chlorine and water?

A. O_2, H_2 and HCl

B. H_2 and OCl_2

C. HCl and HOCl

D. HOCl, H_2 and Cl_2

11. Which statement best describes the **intramolecular** bonding in HCN(l)?

A. Electrostatic attractions between H^{+} and CN^{-} ions

B. Only van der Waals’ forces

C. Van der Waals’ forces and hydrogen bonding

D. Electrostatic attractions between pairs of electrons and positively charged nuclei

12. How many bonding pairs and lone pairs of electrons surround the sulfur atom in the SF_4 molecule?

	Bonding pairs	Lone pairs
A.	4	1
B.	4	0
C.	6	0
D.	8	2

13. Metal M has only one oxidation number and forms a compound with the formula MCO_3. Which formula is correct?

A. MNO_3

B. MNH_4

C. MSO_4

D. MPO_4

14. Which of the following best describes the formation of π bonds?

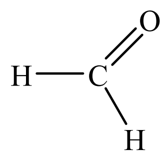
A. They are formed by the sideways overlap of parallel orbitals.

B. They are formed by the axial overlap of orbitals.

C. They are formed by the sideways overlap of an s and p orbital.

D. They are formed by the axial overlap of either s or p orbitals.

15. What is the hybridization of the carbon atom, and the number of σ and π bonds in the methanal molecule?



	Hybridization	σ bonds	π bonds
A.	sp^2	3	1
B.	sp^3	3	1
C.	sp^3	4	0
D.	sp^2	4	0

16. What is the energy, in kJ, released when 1.00 mol of carbon monoxide is burned according to the following equation?

$$2CO(g) + O_2(g) \rightarrow 2CO_2(g) \qquad \Delta H^{\ominus} = -564 \text{ kJ}$$

A. 141

B. 282

C. 564

D. 1128

17. The specific heat of iron is 0.450 J g^{-1} K^{-1}. What is the energy, in J, needed to increase the temperature of 50.0 g of iron by 20.0 K?

A. 9.00

B. 22.5

C. 45.0

D. 450

18. What is the standard entropy change, $\Delta S^{\ominus}$, for the following reaction?

$$2CO(g) + O_2(g) \rightarrow 2CO_2(g)$$

	CO(g)	**O_2(g)**	**CO_2(g)**
$S^{\ominus}$ / J K^{-1} mol^{-1}	198	205	214

A. –189

B. –173

C. +173

D. +189

19. Which step(s) is/are endothermic in the Born-Haber cycle for the formation of LiCl?

A. $\frac{1}{2}Cl_2(g) \rightarrow Cl(g)$ **and** $Li(s) \rightarrow Li(g)$

B. $Cl(g) + e^- \rightarrow Cl^-(g)$ **and** $Li(g) \rightarrow Li^+(g) + e^-$

C. $Li^+(g) + Cl^-(g) \rightarrow LiCl(s)$

D. $\frac{1}{2}Cl_2(g) \rightarrow Cl(g)$ **and** $Cl(g) + e^- \rightarrow Cl^-(g)$

20. What is the function of iron in the Haber process?

A. It shifts the position of equilibrium towards the products.

B. It decreases the rate of the reaction.

C. It provides an alternative reaction pathway with a lower activation energy.

D. It reduces the enthalpy change of the reaction.

21. Consider the following reaction.

$$5Br^-(aq) + BrO_3^-(aq) + 6H^+(aq) \rightarrow 3Br_2(aq) + 3H_2O(l)$$

The rate expression for the reaction is found to be:

$$\text{rate} = k[Br^-][BrO_3^-][H^+]^2$$

Which statement is correct?

A. The overall order is 12.

B. Doubling the concentration of all of the reactants at the same time would increase the rate of the reaction by a factor of 16.

C. The units of the rate constant, k, are $mol\,dm^{-3}\,s^{-1}$.

D. A change in concentration of Br^- or BrO_3^- does not affect the rate of the reaction.

22. The rate expression for a reaction is:

$$\text{rate} = k[X][Y]$$

Which statement is correct?

A. As the temperature increases the rate constant decreases.

B. The rate constant increases with increased temperature but eventually reaches a constant value.

C. As the temperature increases the rate constant increases.

D. The rate constant is not affected by a change in temperature.

23. Consider the following reaction mechanism.

Step 1	$H_2O_2 + I^- \rightarrow H_2O + IO^-$	*slow*
Step 2	$H_2O_2 + IO^- \rightarrow H_2O + O_2 + I^-$	*fast*

Which statement correctly identifies the rate-determining step and the explanation?

A. Step 2 because it is the faster step

B. Step 1 because it is the slower step

C. Step 1 because it is the first step

D. Step 2 because it is the last step

24. Which statement is correct for the equilibrium $H_2O(l) \rightleftharpoons H_2O(g)$ in a closed system at $100\ ^\circ C$?

A. All the $H_2O(l)$ molecules have been converted to $H_2O(g)$.

B. The rate of the forward reaction is greater than the rate of the reverse reaction.

C. The rate of the forward reaction is less than the rate of the reverse reaction.

D. The pressure remains constant.

25. Which are definitions of an acid according to the Brønsted-Lowry and Lewis theories?

	Brønsted-Lowry theory	**Lewis theory**
A.	proton donor	electron pair acceptor
B.	proton acceptor	electron pair acceptor
C.	proton acceptor	electron pair donor
D.	proton donor	electron pair donor

26. 100 cm^3 of a NaOH solution of pH 12 is mixed with 900 cm^3 of water. What is the pH of the resulting solution?

A. 1

B. 3

C. 11

D. 13

27. Ammonia acts as a weak base when it reacts with water. What is the K_b expression for this reaction?

A. $\frac{[NH_4^+][OH^-]}{[NH_3][H_2O]}$

B. $\frac{[NH_3][H_2O]}{[NH_4^+][OH^-]}$

C. $\frac{[NH_3]}{[NH_4^+][OH^-]}$

D. $\frac{[NH_4^+][OH^-]}{[NH_3]}$

28. The indicator, HIn is used in a titration between an acid and base. Which statement about the dissociation of the indicator, HIn is correct?

$$\underset{\text{colour A}}{HIn(aq)} \rightleftharpoons H^+(aq) + \underset{\text{colour B}}{In^-(aq)}$$

A. In a strongly alkaline solution, colour B would be observed.

B. In a strongly acidic solution, colour B would be observed.

C. $[In^-]$ is greater than [HIn] at the equivalence point.

D. In a weakly acidic solution colour B would be observed.

29. At the same concentration, which acid would have the lowest pH?

A. HNO_2 $K_a = 5.6 \times 10^{-4}\ mol\,dm^{-3}$

B. HF $K_a = 6.8 \times 10^{-4}\ mol\,dm^{-3}$

C. C_6H_5COOH $K_a = 6.3 \times 10^{-5}\ mol\,dm^{-3}$

D. HCN $K_a = 4.9 \times 10^{-10}\ mol\,dm^{-3}$

30. Which species is oxidized in the following reaction?

$$2Ag^{+}(aq) + Cu(s) \rightarrow 2Ag(s) + Cu^{2+}(aq)$$

A. Ag^{+}

B. Cu

C. Ag

D. Cu^{2+}

31. Which list represents the halogens in **increasing** order of oxidizing strength (weakest oxidizing agent first)?

A. Cl_2 I_2 Br_2

B. I_2 Br_2 Cl_2

C. I_2 Cl_2 Br_2

D. Cl_2 Br_2 I_2

32. What is the cell potential, in V, for the reaction that occurs when the following two half-cells are connected?

$$Fe^{2+}(aq) + 2e^- \rightleftharpoons Fe(s) \qquad E^\ominus = -0.44 \text{ V}$$

$$Cr_2O_7^{2-}(aq) + 14H^+(aq) + 6e^- \rightleftharpoons 2Cr^{3+}(aq) + 7H_2O(l) \qquad E^\ominus = +1.33 \text{ V}$$

A. +0.01

B. +0.89

C. +1.77

D. +2.65

33. What structural feature must a molecule have in order to undergo addition polymerization?

A. Two functional groups

B. A carbon–carbon double bond

C. Carbon atoms singly bonded together

D. A polar covalent bond

34. What is the product of the oxidation of butan-2-ol?

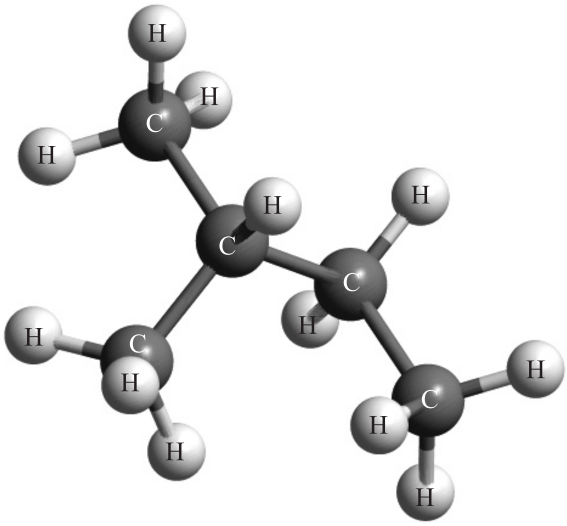
A. But-2-ene

B. Butanoic acid

C. Butanal

D. Butanone

35. What is the IUPAC name of the following compound?



A. 2-methylbutane

B. Ethylpropane

C. 3-methylbutane

D. Pentane

36. Which equations represent the incomplete combustion of methane?

I. $CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g)$

II. $CH_4(g) + 1\frac{1}{2}O_2(g) \rightarrow CO(g) + 2H_2O(g)$

III. $CH_4(g) + O_2(g) \rightarrow C(s) + 2H_2O(g)$

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

37. What is the organic product of the reaction between $CH_3CH_2NH_2$ and CH_3CH_2COOH?

A. $CH_3CH_2NHCOCH_2CH_3$

B. $CH_3CH_2CH_2NHCOCH_3$

C. $CH_3CH_2NHCOCH_3$

D. $CH_3NHCOCH_3$

38. What is the IUPAC name of the compound $CH_3CH_2COOCH_2CH_3$?

A. Ethyl ethanoate

B. Propyl ethanoate

C. Ethyl propanoate

D. Pentyl propanoate

39. Which statement is correct about the enantiomers of a chiral compound?

A. Their physical properties are different.

B. All their chemical reactions are identical.

C. A racemic mixture will rotate the plane of polarized light.

D. They will rotate the plane of polarized light in opposite directions.

40. Which would be the best method to decrease the **random** uncertainty of a measurement in an acid-base titration?

A. Repeat the titration

B. Ensure your eye is at the same height as the meniscus when reading from the burette

C. Use a different burette

D. Use a different indicator for the titration