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CHEMISTRY
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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. Which compound has the empirical formula with the largest mass?

A. C_2H_6

B. C_2H_4

C. C_2H_2

D. C_3H_6

2. 5 dm^3 of carbon monoxide, CO (g), and 2 dm^3 of oxygen, O_2(g), at the same temperature and pressure are mixed together. Assuming complete reaction according to the equation given, what is the maximum volume of carbon dioxide, CO_2(g), in dm^3, that can be formed?

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

A. 3

B. 4

C. 5

D. 7

3. Which statement about solutions is correct?

A. When vitamin D dissolves in fat, vitamin D is the solvent and fat is the solute.

B. In a solution of NaCl in water, NaCl is the solute and water is the solvent.

C. An aqueous solution consists of water dissolved in a solute.

D. The concentration of a solution is the amount of solvent dissolved in 1 dm^3 of solution.

4. Which is correct for the following regions of the electromagnetic spectrum?

	UV		IR	
A.	high energy	short wavelength	low energy	low frequency
B.	high energy	low frequency	low energy	long wavelength
C.	high frequency	short wavelength	high energy	long wavelength
D.	high frequency	long wavelength	low frequency	low energy

5. Which species possesses only two unpaired electrons?

A. Zn

B. Mg

C. Ti^{2+}

D. Fe^{2+}

6. Which is the best definition of *electronegativity*?

A. Electronegativity is the energy required for a gaseous atom to gain an electron.

B. Electronegativity is the attraction of an atom for a bonding pair of electrons.

C. Electronegativity is the attraction between the nucleus and the valence electrons of an atom.

D. Electronegativity is the ability of an atom to attract electrons from another atom.

7. Which statements are correct for the reactions of Cl_2 , $MgCl_2$ and $SiCl_4$ with water?

	Cl_2	$MgCl_2$	$SiCl_4$
A.	forms a neutral solution	forms a neutral solution	no reaction
B.	forms an acidic solution	forms an acidic solution	forms an acidic solution
C.	forms an acidic solution	forms an acidic solution	no reaction
D.	forms a neutral solution	forms a neutral solution	forms an acidic solution

8. Which transition element, or compound of a transition element, is used as a catalyst in the Contact process?

A. Fe

B. MnO_2

C. V_2O_5

D. Ni

9. Which is the best description of ionic bonding?

A. The electrostatic attraction between positively charged nuclei and an electron pair

B. The electrostatic attraction between positive ions and delocalized negative ions

C. The electrostatic attraction between positive ions and delocalized electrons

D. The electrostatic attraction between oppositely charged ions

10. Which statements best describe the structure of sodium chloride, NaCl?

I. Each sodium ion is surrounded by six chloride ions.

II. The chloride ions are arranged octahedrally around each sodium ion.

III. The lattice forms a cubic structure.

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

11. Which molecule contains a dative covalent (coordinate) bond?

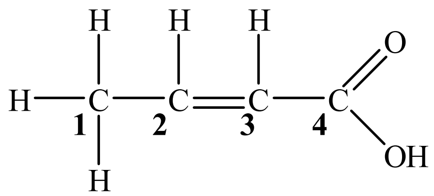
A. HCN

B. H_2O_2

C. CO_2

D. CO

12. Identify the hybridization of carbon atoms in this molecule



	1	2	3	4
A.	sp^3	sp^2	sp^2	sp^2
B.	sp^2	sp^2	sp^2	sp
C.	sp^3	sp	sp^2	sp
D.	sp	sp^2	sp	sp^2

13. Which structure has delocalized π electrons?

A. O_3

B. CO

C. HCN

D. CO_2

14. 1.0 g of sodium hydroxide, NaOH, was added to 99.0 g of water. The temperature of the solution increased from 18.0 °C to 20.5 °C. The specific heat capacity of the solution is 4.18 J g^{-1} K^{-1}. Which expression gives the heat evolved in kJ mol^{-1}?

A. $\dfrac{2.5 \times 100.0 \times 4.18 \times 1000}{40.0}$

B. $\dfrac{2.5 \times 100.0 \times 4.18}{1000 \times 40.0}$

C. $\dfrac{2.5 \times 100.0 \times 4.18 \times 40.0}{1000}$

D. $\dfrac{2.5 \times 1.0 \times 4.18 \times 40.0}{1000}$

15. Which process represents the C–Cl bond enthalpy in tetrachloromethane?

A. $CCl_4(g) \rightarrow C(g) + 4Cl(g)$

B. $CCl_4(g) \rightarrow CCl_3(g) + Cl(g)$

C. $CCl_4(l) \rightarrow C(g) + 4Cl(g)$

D. $CCl_4(l) \rightarrow C(s) + 2Cl_2(g)$

16. Which reaction has the greatest increase in entropy?

A. $C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(g)$

B. $H_2(g) + Cl_2(g) \rightarrow 2HCl(g)$

C. $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$

D. $C_2H_4(g) + H_2(g) \rightarrow C_2H_6(g)$

17. The reaction between but-1-ene and water vapour produces butan-1-ol.

$$C_4H_8(g) + H_2O(g) \rightarrow C_4H_9OH(l)$$

The standard entropy values ($S^{\ominus}$) for but-1-ene, water vapour and butan-1-ol are 310, 189 and 228 J K^{-1} mol^{-1} respectively. What is the standard entropy change for this reaction in J K^{-1} mol^{-1}?

A. –271

B. +271

C. –107

D. +107

18. A reaction has a standard enthalpy change, $\Delta H^{\ominus}$, of +10.00 kJ mol^{-1} at 298 K. The standard entropy change, $\Delta S^{\ominus}$, for the same reaction is +10.00 J K^{-1} mol^{-1}. What is the value of $\Delta G^{\ominus}$ for the reaction in kJ mol^{-1}?

A. +9.75

B. +7.02

C. –240

D. –2970

19. What is the best definition of *rate of reaction*?

A. The time it takes to use up all the reactants

B. The rate at which all the reactants are used up

C. The time it takes for one of the reactants to be used up

D. The increase in concentration of a product per unit time

20. Which factors can affect reaction rate?

I. The state of the reactants

II. The frequency of the collisions between particles

III. The average kinetic energy of the particles

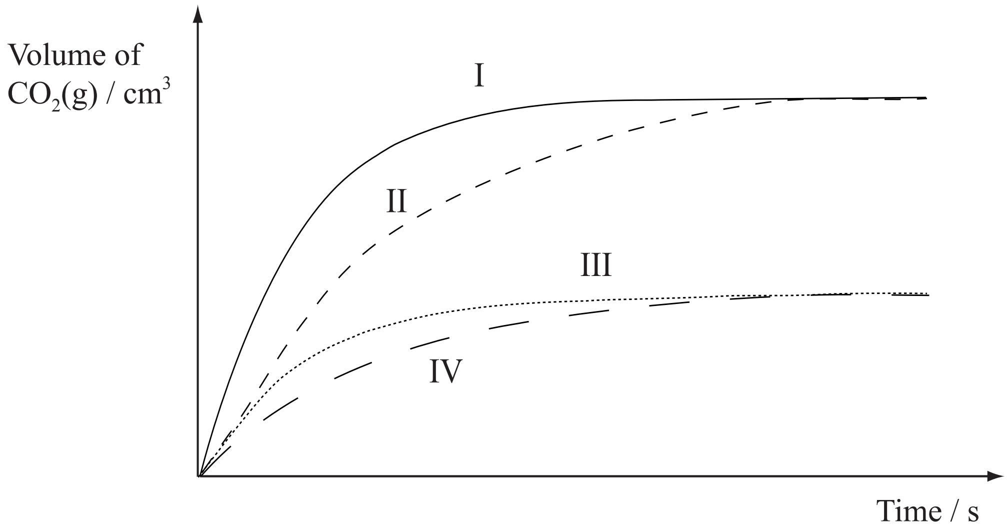
A. I and II only

B. I and III only

C. II and III only

D. I, II and III

21. Equal masses of powdered calcium carbonate were added to separate solutions of hydrochloric acid. The calcium carbonate was in excess. The volume of carbon dioxide produced was measured at regular intervals. Which curves best represent the evolution of carbon dioxide against time for the acid solutions shown in the table below.



	25 cm^3 of 2 mol dm^{-3} HCl	**50 cm^3 of 1 mol dm^{-3} HCl**	**25 cm^3 of 1 mol dm^{-3} HCl**
A.	I	III	IV
B.	I	IV	III
C.	I	II	III
D.	II	I	III

Questions 22 and 23 refer to the following reaction.

$$X_2 + 2Y \rightarrow 2XY$$

The reaction occurs in a series of steps.

$X_2 \rightarrow 2X$	*slow*
$X + Y \rightarrow XY$	*fast*

22. What is the rate-determining step for this reaction mechanism?

A. $X_2 + 2Y \rightarrow 2XY$

B. $X_2 + Y \rightarrow XY + X$

C. $X_2 \rightarrow 2X$

D. $X + Y \rightarrow XY$

23. What is the rate expression for this reaction?

A. rate = k [XY]

B. rate = k $[X_2][Y]^2$

C. rate = k $[X_2]$

D. rate = k [2X]

24. Consider the following reversible reaction.

$$Cr_2O_7^{2-}(aq) + H_2O(l) \rightleftharpoons 2CrO_4^{2-}(aq) + 2H^+(aq)$$

What will happen to the position of equilibrium and the value of K_c when more H^+ ions are added at constant temperature?

	Position of equilibrium	**Value of K_c**
A.	shifts to the left	decreases
B.	shifts to the right	increases
C.	shifts to the right	does not change
D.	shifts to the left	does not change

25. Consider this equilibrium reaction in a sealed container:

$$H_2O(g) \rightleftharpoons H_2O(l)$$

What will be the effect on the equilibrium of increasing the temperature from 20 °C to 30 °C?

A. More of the water will be in the gaseous state at equilibrium.

B. More of the water will be in the liquid state at equilibrium.

C. At equilibrium the rate of condensation will be greater than the rate of evaporation.

D. At equilibrium the rate of evaporation will be greater than the rate of condensation.

26. When equal volumes of four 0.1 mol dm^{-3} solutions are arranged in order of increasing pH (lowest pH first), what is the correct order?

A. $CH_3COOH < HNO_3 < CH_3CH_2NH_2 < KOH$

B. $HNO_3 < CH_3COOH < CH_3CH_2NH_2 < KOH$

C. $CH_3CH_2NH_2 < HNO_3 < CH_3COOH < KOH$

D. $KOH < CH_3CH_2NH_2 < CH_3COOH < HNO_3$

27. What is the correct expression for the ionic product constant of water, K_w?

A. $K_W = \frac{[H^+]}{[OH^-]}$

B. $K_W = \frac{[H_2O]}{[H^+][OH^-]}$

C. $K_W = [H^+]+[OH^-]$

D. $K_W = [H^+][OH^-]$

28. Which mixtures could act as buffers?

I. $NaOH(aq)$ and $HCl(aq)$

II. $NaOH(aq)$ and $CH_3COOH(aq)$

III. $HCl(aq)$ and $CH_3COONa(aq)$

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

29. What is the approximate pH of a 0.01 mol dm^{-3} ammonia solution?

A. 2

B. More than 2 but less than 7

C. More than 7 but less than 12

D. 12

30. What happens at the negative electrode in a voltaic cell and in an electrolytic cell?

	Voltaic cell	**Electrolytic cell**
A.	oxidation	reduction
B.	reduction	oxidation
C.	oxidation	oxidation
D.	reduction	reduction

31. Which conditions are usually stated for a standard hydrogen electrode?

I. Hydrogen gas at a pressure of 1.01×10^5 Pa (1 atm)

II. 1.0 mol dm^{-3} solution of any acid

III. Temperature of 25 ºC (298 K)

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

32. Consider these standard electrode potentials.

$$Mg^{2+}(aq) + 2e^- \rightleftharpoons Mg(s) \qquad E^\ominus = -2.36\ V$$
$$Zn^{2+}(aq) + 2e^- \rightleftharpoons Zn(s) \qquad E^\ominus = -0.76\ V$$

What is the cell potential for the voltaic cell produced when the two half-cells are connected?

A. –1.60 V

B. +1.60 V

C. –3.12 V

D. +3.12 V

33. Which three compounds can be considered to be a homologous series?

A. CH_3OH, CH_3CH_2OH, $CH_3CH_2CH_2OH$

B. CH_3CH_2OH, CH_3CHO, CH_3COOH

C. $CH_3CH_2CH(OH)CH_3$, $CH_3CH_2CH_2CH_2OH$, $(CH_3)_3COH$

D. $CH_3CH_2CH_2CH_2OH$, $CH_3CH_2OCH_2CH_3$, $(CH_3)_2CH_2CHO$

34. Identify the functional group present in $HCOCH_2CH_3$.

A. Ester

B. Ketone

C. Aldehyde

D. Alcohol

35. What is the IUPAC name for $HCOOCH_2CH_2CH_3$?

A. Butanoic acid

B. Butanal

C. Methyl propanoate

D. Propyl methanoate

36. Which conditions are required to obtain a good yield of a carboxylic acid when ethanol is oxidized using potassium dichromate(VI), $K_2Cr_2O_7(aq)$?

I. Add sulfuric acid

II. Heat the reaction mixture under reflux

III. Distil the product as the oxidizing agent is added

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

37. Which statements about substitution reactions are correct?

I. The reaction between sodium hydroxide and 1-chloropentane predominantly follows an S_N2 mechanism.

II. The reaction between sodium hydroxide and 2-chloro-2-methylbutane predominantly follows an S_N2 mechanism.

III. The reaction of sodium hydroxide with 1-chloropentane occurs at a slower rate than with 1-bromopentane.

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

38. What is the organic product of the reaction between methylamine and ethanoic acid?

A. CH_3COONH_4

B. $CH_3NHCOCH_3$

C. $CH_3COCH_2NH_2$

D. $CH_3CH_2CONH_2$

39. Which compound can exist as stereoisomers?

A. CH_3CH_2CHO

B. $CH_3CH_2COCH_3$

C. $CH_3CH(CH_3)_2$

D. $CH_3CH_2CHOHCH_3$

40. A student recorded the volume of a gas as 0.01450 dm^3. How many significant figures are there in this value?

A. 3

B. 4

C. 5

D. 6