N09/4/CHEMI/HPM/ENG/TZ0/XX+

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CHEMISTRY
HIGHER LEVEL
PAPER 1

Tuesday 3 November 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 coefficients would balance this equation?

$$\_\_ \; MnO_2 + \_\_ \; HCl \rightarrow \_\_ \; MnCl_2 + \_\_ \; Cl_2 + \_\_ \; H_2O$$

	MnO_2	HCl	$MnCl_2$	Cl_2	H_2O
A.	1	2	1	1	1
B.	1	3	1	1	1
C.	1	4	1	1	2
D.	1	4	1	2	2

2. What volume of carbon dioxide, in dm^3 under standard conditions, is formed when 7.00 g of ethene (C_2H_4, $M_r = 28.1$) undergoes complete combustion?

A. $\dfrac{22.4 \times 28.1}{7.00}$

B. $\dfrac{22.4 \times 7.00}{28.1}$

C. $\dfrac{2 \times 22.4 \times 28.1}{7.00}$

D. $\dfrac{2 \times 22.4 \times 7.00}{28.1}$

3. What will be the concentration of sulfate ions in $mol\,dm^{-3}$ when 0.20 mol of $KAl(SO_4)_2$ is dissolved in water to give 100 cm^3 of aqueous solution?

A. 0.2

B. 1.0

C. 2.0

D. 4.0

4. The volume of an ideal gas at 27.0 °C is increased from 3.00 dm^3 to 6.00 dm^3. At what temperature, in °C, will the gas have the original pressure?

A. 13.5

B. 54.0

C. 327

D. 600

5. Which gives the correct order of these processes in a mass spectrometer?

A.	ionization	deflection	acceleration
B.	ionization	acceleration	deflection
C.	acceleration	ionization	deflection
D.	deflection	acceleration	ionization

6. Between which ionization energies of boron will there be the greatest difference?

A. Between 1st and 2nd ionization energies

B. Between 2nd and 3rd ionization energies

C. Between 3rd and 4th ionization energies

D. Between 4th and 5th ionization energies

7. What happens when sodium is added to water?

I. A gas is evolved

II. The temperature of the water increases

III. A clear, colourless solution is formed

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

8. Which species has the largest radius?

A. Cl^-

B. K

C. Na^+

D. K^+

9. Which process is responsible for the colour of a transition metal complex?

A. The absorption of light when electrons move between s orbitals and d orbitals

B. The emission of light when electrons move between s orbitals and d orbitals

C. The absorption of light when electrons move between different d orbitals

D. The emission of light when electrons move between different d orbitals

10. What is the correct order if the compounds are arranged in order of increasing boiling point?

A. $CH_4 < CH_3Cl < SiH_4 < CH_3OH$

B. $CH_3OH < CH_4 < CH_3Cl < SiH_4$

C. $CH_3OH < CH_3Cl < SiH_4 < CH_4$

D. $CH_4 < SiH_4 < CH_3Cl < CH_3OH$

11. What is the bond angle in the H_3O^+ ion?

A. 104°

B. 107°

C. 109°

D. 120°

12. Which compound does **not** form hydrogen bonds between its molecules?

A. CH_3NH_2

B. CH_3COCH_3

C. CH_3COOH

D. CH_3CH_2OH

13. How many atoms is each carbon directly bonded to in its allotropes?

	Diamond	**Graphite**	**C_{60} fullerene**
A.	3	3	3
B.	4	3	3
C.	4	3	4
D.	4	4	3

14. What is the type of hybridization of the silicon and oxygen atoms in silicon dioxide?

	Silicon	**Oxygen**
A.	sp^3	sp^3
B.	sp^3	sp^2
C.	sp^2	sp^3
D.	sp^2	sp^2

15. In a reaction that occurs in 50 g of aqueous solution, the temperature of the reaction mixture increases by 20 °C. If 0.10 mol of the limiting reagent is consumed, what is the enthalpy change (in kJ mol^{-1}) for the reaction? Assume the specific heat capacity of the solution = 4.2 kJ kg^{-1} K^{-1}.

A. $-0.10 \times 50 \times 4.2 \times 20$

B. $-0.10 \times 0.050 \times 4.2 \times 20$

C. $\dfrac{-50 \times 4.2 \times 20}{0.10}$

D. $\dfrac{-0.050 \times 4.2 \times 20}{0.10}$

16. Use the average bond enthalpies below to calculate the enthalpy change, in kJ, for the following reaction.

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

Bond	**Bond energy / kJ mol^{-1}**
H–H	440
I–I	150
H–I	300

A. +290

B. +10

C. –10

D. –290

17. Which ionic compound has the most endothermic lattice enthalpy?

A. NaCl

B. KCl

C. NaF

D. KF

18. Which change leads to an increase in entropy?

A. $CO_2(g) \rightarrow CO_2(s)$

B. $SF_6(g) \rightarrow SF_6(l)$

C. $H_2O(l) \rightarrow H_2O(s)$

D. $NaCl(s) \rightarrow NaCl(aq)$

19. Hydrochloric acid is reacted with large pieces of calcium carbonate, the reaction is then repeated using calcium carbonate powder. How does this change affect the activation energy and the collision frequency?

	Activation energy	**Collision frequency**
A.	increases	increases
B.	stays constant	increases
C.	increases	stays constant
D.	stays constant	stays constant

20. Two species, P and Q, react together according to the following equation.

$$P + Q \rightarrow R$$

The accepted mechanism for this reaction is

$$P + P \rightleftharpoons P_2 \qquad \textit{fast}$$
$$P_2 + Q \rightarrow R + P \qquad \textit{slow}$$

What is the order with respect to P and Q?

	P	**Q**
A.	1	1
B.	1	2
C.	2	1
D.	2	2

21. The activation energy of a reaction may be determined by studying the effect of a particular variable on the reaction rate. Which variable must be changed?

A. pH

B. Concentration

C. Surface area

D. Temperature

22. An increase in temperature increases the amount of chlorine present in the following equilibrium.

$$PCl_5(s) \rightleftharpoons PCl_3(l) + Cl_2(g)$$

What is the best explanation for this?

A. The higher temperature increases the rate of the forward reaction only.

B. The higher temperature increases the rate of the reverse reaction only.

C. The higher temperature increases the rate of both reactions but the forward reaction is affected more than the reverse.

D. The higher temperature increases the rate of both reactions but the reverse reaction is affected more than the forward.

23. Which affects the equilibrium vapour pressure of a liquid in a sealed container, assuming that there is always some of the liquid present?

A. The temperature of the liquid

B. The surface area of the liquid

C. The volume of the liquid

D. The volume of the container

24. According to the Brønsted-Lowry theory, how does each species act in the equilibrium below?

$$CH_3COOH + H_2SO_4 \rightleftharpoons CH_3COOH_2^+ + HSO_4^-$$

	CH_3COOH	**H_2SO_4**	**$CH_3COOH_2^+$**	**HSO_4^-**
A.	acid	base	base	acid
B.	acid	base	acid	base
C.	base	acid	base	acid
D.	base	acid	acid	base

25. If 20 cm^3 samples of 0.1 $mol\,dm^{-3}$ solutions of the acids below are taken, which acid would require a different volume of 0.1 $mol\,dm^{-3}$ sodium hydroxide for complete neutralization?

A. Nitric acid

B. Sulfuric acid

C. Ethanoic acid

D. Hydrochloric acid

26. Which mixture of acid and alkali would produce a buffer solution?

	Acid	**Alkali**
A.	40 cm^3 0.1 $mol\,dm^{-3}$ HCl	60 cm^3 0.1 $mol\,dm^{-3}$ NaOH
B.	60 cm^3 0.1 $mol\,dm^{-3}$ HCl	40 cm^3 0.1 $mol\,dm^{-3}$ NaOH
C.	40 cm^3 0.1 $mol\,dm^{-3}$ HCl	60 cm^3 0.1 $mol\,dm^{-3}$ NH_3
D.	60 cm^3 0.1 $mol\,dm^{-3}$ HCl	40 cm^3 0.1 $mol\,dm^{-3}$ NH_3

27. Which aqueous solution would have a pH > 7?

A. Sodium sulfate

B. Ammonium nitrate

C. Sodium ethanoate

D. Aluminium nitrate

28. Which indicator would be the most appropriate for titrating aqueous ethylamine, $CH_3CH_2NH_2$, with nitric acid, HNO_3?

A. Bromophenol blue ($pK_a = 4.1$)

B. Bromothymol blue ($pK_a = 7.3$)

C. Phenol red ($pK_a = 8.0$)

D. Thymolphthalein ($pK_a = 10.0$)

29. Which compound contains nitrogen with an oxidation number of +3?

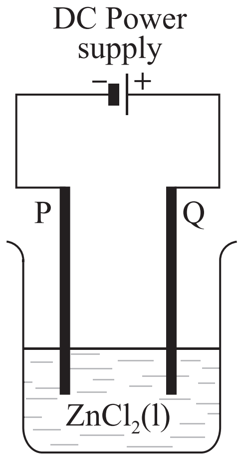
A. NH_4Cl

B. HNO_3

C. N_2O_4

D. KNO_2

30. In the electrolytic cell shown, at which electrode will chlorine form, and what is the process taking place there?



	Electrode	Process
A.	P	reduction
B.	Q	reduction
C.	P	oxidation
D.	Q	oxidation

31. Which are necessary conditions for the standard hydrogen electrode to have an $E^{\ominus}$ of exactly zero?

I. Temperature = 298 K

II. $[H^+] = 1\ mol\,dm^{-3}$

III. $[H_2] = 1\ mol\,dm^{-3}$

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

32. How do the products compare at each electrode when aqueous 1 mol dm^{-3} magnesium bromide and molten magnesium bromide are electrolysed?

			$E^{\ominus}$ / V
$Mg^{2+}(aq) + 2e^-$	$\rightleftharpoons$	$Mg(s)$	-2.37
$\frac{1}{2}Br_2(l) + e^-$	$\rightleftharpoons$	$Br^-(aq)$	$+1.07$
$\frac{1}{2}O_2(g) + 2H^+(aq) + 2e^-$	$\rightleftharpoons$	$H_2O(l)$	$+1.23$

	Positive electrode (Anode)	Negative electrode (Cathode)
A.	same	same
B.	same	different
C.	different	same
D.	different	different

33. How many **structural** isomers exist with the formula $C_3H_5Cl_3$?

A. 3

B. 4

C. 5

D. 6

34. Which reaction occurs via a free-radical mechanism?

A. $C_2H_6 + Br_2 \rightarrow C_2H_5Br + HBr$

B. $C_2H_4 + Br_2 \rightarrow C_2H_4Br_2$

C. $C_4H_9I + OH^- \rightarrow C_4H_9OH + I^-$

D. $(CH_3)_3CI + H_2O \rightarrow (CH_3)_3COH + HI$

35. Which substance is produced by the reaction of hydrogen with a vegetable oil?

A. Margarine

B. Nylon

C. Polypropene

D. Soap

36. Propene is converted to propanone in a two stage process.

$$\text{Propene} \rightarrow \text{X} \rightarrow \text{Propanone}$$

What is the formula of compound X?

A. $CH_3CHBrCH_3$

B. $CH_3CH_2CH_2Br$

C. $CH_3CHOHCH_3$

D. $CH_3CH_2CH_2OH$

37. Which compound could rotate the plane of polarization of polarized light?

A. $(CH_3)_2CHCH_2Cl$

B. $CH_3CH_2CH_2CH_2Cl$

C. $CH_3CH_2CHClCH_3$

D. $(CH_3)_3CCl$

38. What is the name of the ester formed when CH_3CH_2COOH and CH_3OH react together?

A. Ethyl methanoate

B. Methyl ethanoate

C. Propyl methanoate

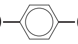
D. Methyl propanoate

39. Which formula represents a polyamide?

A. $\left(CH_2-CHCl \right)_n$

B. $\left(NH-(CH_2)_6-NH-CO-(CH_2)_4-CO \right)_n$

C. $\left(CF_2-CF_2 \right)_n$

D. $\left(O-(CH_2)_2-O-CO-$  $-CO \right)_n$

40. Which are likely to be reduced when an experiment is repeated a number of times?

A. Random errors

B. Systematic errors

C. Both random and systematic errors

D. Neither random nor systematic errors