

CORK INSTITUTE OF TECHNOLOGY
INSTITIÚID TEICNEOLAÍOCHTA CHORCAÍ

Autumn Examinations 2012

Module Title: Bioanalytical Science III

Module Code: CHEA6003

School: Science & Informatics

Programme Title: Bachelor of Science in Applied Biosciences
Bachelor of Science (Hons) in Pharmaceutical Biotechnology
Bachelor of Science (Hons) in Nutrition and Health Science

Programme Code: SBIOS_7_Y2
SPHBI_8_Y2
SNHSC_8_Y2

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Ms E. Norris

Instructions: **Attempt Three questions.**
Section A, Question 1 is compulsory.
Attempt any two questions from Section B
Show all calculations and rough work on the answer book.

Duration: 2 Hours

Sitting: Autumn 2012

Requirements for this examination: Periodic Table

<p>Note to Candidates: Please check the Programme Title and the Module Title to ensure that you have received the correct examination paper. If in doubt please contact an Invigilator.</p>
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SECTION A – COMPULSORY

Q1. Attempt any 8 of the following 12 parts. All carry equal marks.

- (i) Distinguish, giving examples in each case, between the following **4 classifications of electrons**: closed shell electrons; covalent single bond electrons; paired non-bonding outer shell electrons; pi electrons.
- (ii) Explain the letters **ISE**. Name the **four** common types. List **three** particulars of ISE's. Comment on their reliability.
- (iii) Detectors are ranked using the following terms, sensitivity stability, linearity, universality and selectivity. Explain any **three** of these terms
- (iv) Determine the volume required, in cm^3 , of concentrated sulphuric acid (H_2SO_4) 94% (g/100g solution), density 1.831 g cm^{-3} , to prepare 500 cm^3 of a $0.250 \text{ mol dm}^{-3}$ solution.
- (v) A solution containing 5.00 mg of potassium in 200 cm^3 of water was observed to transmit 75% of the incident radiation compared to the appropriate blank.
 - (a) What is the absorbance of the solution at this wavelength?
 - (b) What % of light would be transmitted by a solution three times as concentrated?
 - (c) What is the concentration in mol dm^{-3} .
Mr. for K = 39 g mol^{-1}
- (vi) A 30 cm^3 sample of cough medicine was analysed and found to contain 50mg of glucose. Express the concentration of glucose in ppb and ppm.
- (vii) Give a description of the infra-red and visible regions of the electromagnetic spectrum. Include detail about common properties and differences between these wavelength regions. What is the wavelength range for the infra-red, and visible parts of the electromagnetic spectrum? What is the relationship between frequency and wavelength of an electromagnetic wave?
- (viii) Give a brief description of the physics of:
 - (a) Emission Spectroscopy
 - (b) Scattering Spectroscopy

- (ix) CCDs are frequently used for light detection and measurement. What do the letters CCD stand for? Give a simple description of the structure of a CCD and thereby explain how a CCD measures light.
- (x) Draw a fully labelled block diagram of the optical layout for a double beam spectrometer. What is the function of a double beam arrangement?
- (xi) Most spectroscopic analysis techniques require electromagnetic radiation to have *narrow bandwidth*. Explain what 'narrow bandwidth' means. Why is a narrow bandwidth desirable for spectroscopic applications? List three methods/techniques for achieving narrow bandwidth light source.
- (xii) Reflection gratings are an important component in spectroscopic instrumentation. What function does the reflection grating perform? Write down the grating equation and identify each variable. A 1400 groove/mm diffraction grating is used in a monochromator and is set to diffract at 400 nm. Calculate the diffracted angle of light if light is incident on the grating at 10.00° .

(40 marks total)

SECTION B

Attempt any two of the following three questions. All carry equal marks.

- Q2.** (i) Compare and contrast molecular Ultra violet visible spectroscopy and Fluorimetry under the following headings:
- (a) sample type
 - (b) method sensitivity and limit of detection
 - (c) qualitative and quantitative applications. (10 marks)
- (ii) A multi-vitamin tablet was analysed for riboflavin (vitamin B2) content according to literature methods. A series of standards were prepared from a 1.00ppm riboflavin stock solution. Their fluorescence intensity, (FI), values were determined and are given in the table below.
- The FI of the vitamin tablet sample was determined in triplicate results are also included in the table. As can be seen, these FI values are outside the range of the standards. A one in five dilution was necessary to bring these values on scale. The analysis results for the diluted sample can be seen on the data table too.
- (a) Draw the appropriate calibration curve and determine the concentration of riboflavin in the multi-vitamin tablet sample.
 - (b) Explain the process of how the dilution of the sample was achieved.
 - (c) What volume of the stock solution is required to prepare 100cm³ of the 0.03mgdm³ standard solution?

Fluorescence Intensity (FI)	Concentration / mgdm ⁻³
173.80	0.010
353.20	0.020
504.7	0.030
675.9	0.040
850.2	0.050

Sample Data

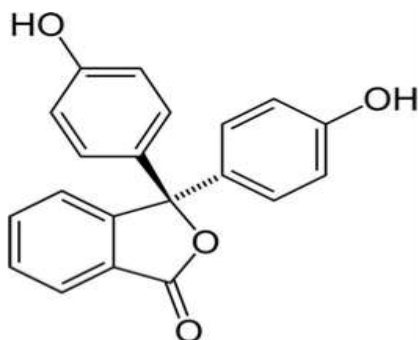
FI

multi-vitamin sample	999.9
	998.9
	999.7.
Diluted sample	313.2
	312.3
	314.1.

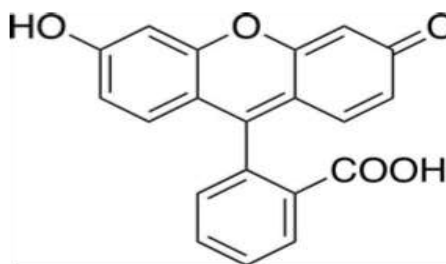
(15 marks)

- (iii) Consider the two molecules given below which compound would you expect to give the greatest fluorescence quantum yield? Explain your answer.

(5marks)



COMPOUND A



COMPOUND B

Q3. Attempt 3 of the following 5 parts

All carry equal marks.

(10 marks each)

- (i) Illustrate, with a well labelled diagram, the conductimetric titration curve obtained when a weak acid is titrated against a strong base. Detail the ions responsible for the conductivity before, at and after the endpoint of the titration. Show on your graph how the endpoint is determined.
- (ii) Chromatography peaks/bands broaden as they move through a column. Describe three methods of band broadening giving appropriate diagrams in each case. How does each method depend on flow rate?
- (iii) (a) What is analytical chemistry? Outline the steps involved in any analytical process.
(b) Sampling is the process of selecting a representative bulk sample from the lot. Sample preparation is the process that converts a bulk sample into a homogenous laboratory sample. Sometimes in analysis it is necessary to mask an interfering species. Explain the underlined terms.
- (iv) (a) Conjugated systems and aromatic systems interact similarly with ultraviolet and visible radiation. Explain the basis for these interactions; include examples in your discussion.
(b) Explain the term auxochrome. What effect does its inclusion in a molecule have on the absorption position and intensity of a chromophore? Give at least one example to illustrate these effects.
- (v) In biological systems quantitative measurements are often made in the UV-Visible region of the electromagnetic spectrum (200 – 800 nm). In situations where this is impossible since the material absorbs outside this region a complex or a chelate of the compound under investigation may be formed which does.

An ideal chelating reagent must possess a number of important characteristics, list and explain briefly **three** of these characteristics.

- Q4.**
- (i) Describe in detail the method of partition chromatography. In your description identify the mobile and stationary phases used and typical sample type. A simple diagram is required. (15 marks)
 - (ii) List three other chromatographic separation methods, giving the appropriate sample type in each case. (6 marks)
 - (iii) What is an internal standard and why is it included in chromatographic analysis? Hence or otherwise explain the terms relative peak area and response factor. (9 marks)

Periodic Table of Elements

VIII A		II A																III A																IV A				V A				VI A				VII A				VIII A																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
1	H	3	Li	4	Be	11	Na	12	Mg	19	K	20	Ca	21	Sc	22	Ti	23	V	24	Cr	25	Mn	26	Fe	27	Co	28	Ni	29	Cu	30	Zn	31	Ga	32	Ge	33	As	34	Se	35	Br	36	Kr	37	Rb	38	Sr	39	Y	40	Zr	41	Nb	42	Mo	43	Tc	44	Ru	45	Rh	46	Pd	47	Ag	48	Cd	49	In	50	Sn	51	Sb	52	Te	53	I	54	Xe	55	Cs	56	Ba	57	La	87	Fr	88	Ra	89	Ac	90	Th	91	Pa	92	U	93	Np	94	Pu	95	Am	96	Cm	97	Bk	98	Cf	99	Es	100	Lr	101	La	102	Hf	103	Ta	104	W	105	Re	106	Os	107	Ir	108	Pt	109	Au	110	Hg	111	Tl	112	Pb	113	Bi	114	Po	115	At	116	Rn	117	Fr	118	Ra	119	Ac	120	Th	121	Pa	122	U	123	Np	124	Pu	125	Am	126	Cm	127	Bk	128	Cf	129	Es	130	Lr	131	La	132	Hf	133	Ta	134	W	135	Re	136	Os	137	Ir	138	Pt	139	Au	140	Hg	141	Tl	142	Pb	143	Bi	144	Po	145	At	146	Rn	147	Fr	148	Ra	149	Ac	150	Th	151	Pa	152	U	153	Np	154	Pu	155	Am	156	Cm	157	Bk	158	Cf	159	Es	160	Lr	161	La	162	Hf	163	Ta	164	W	165	Re	166	Os	167	Ir	168	Pt	169	Au	170	Hg	171	Tl	172	Pb	173	Bi	174	Po	175	At	176	Rn	177	Fr	178	Ra	179	Ac	180	Th	181	Pa	182	U	183	Np	184	Pu	185	Am	186	Cm	187	Bk	188	Cf	189	Es	190	Lr	191	La	192	Hf	193	Ta	194	W	195	Re	196	Os	197	Ir	198	Pt	199	Au	200	Hg	201	Tl	202	Pb	203	Bi	204	Po	205	At	206	Rn	207	Fr	208	Ra	209	Ac	210	Th	211	Pa	212	U	213	Np	214	Pu	215	Am	216	Cm	217	Bk	218	Cf	219	Es	220	Lr	221	La	222	Hf	223	Ta	224	W	225	Re	226	Os	227	Ir	228	Pt	229	Au	230	Hg	231	Tl	232	Pb	233	Bi	234	Po	235	At	236	Rn	237	Fr	238	Ra	239	Ac	240	Th	241	Pa	242	U	243	Np	244	Pu	245	Am	246	Cm	247	Bk	248	Cf	249	Es	250	Lr	251	La	252	Hf	253	Ta	254	W	255	Re	256	Os	257	Ir	258	Pt	259	Au	260	Hg	261	Tl	262	Pb	263	Bi	264	Po	265	At	266	Rn	267	Fr	268	Ra	269	Ac	270	Th	271	Pa	272	U	273	Np	274	Pu	275	Am	276	Cm	277	Bk	278	Cf	279	Es	280	Lr	281	La	282	Hf	283	Ta	284	W	285	Re	286	Os	287	Ir	288	Pt	289	Au	290	Hg	291	Tl	292	Pb	293	Bi	294	Po	295	At	296	Rn	297	Fr	298	Ra	299	Ac	300	Th	301	Pa	302	U	303	Np	304	Pu	305	Am	306	Cm	307	Bk	308	Cf	309	Es	310	Lr	311	La	312	Hf	313	Ta	314	W	315	Re	316	Os	317	Ir	318	Pt	319	Au	320	Hg	321	Tl	322	Pb	323	Bi	324	Po	325	At	326	Rn	327	Fr	328	Ra	329	Ac	330	Th	331	Pa	332	U	333	Np	334	Pu	335	Am	336	Cm	337	Bk	338	Cf	339	Es	340	Lr	341	La	342	Hf	343	Ta	344	W	345	Re	346	Os	347	Ir	348	Pt	349	Au	350	Hg	351	Tl	352	Pb	353	Bi	354	Po	355	At	356	Rn	357	Fr	358	Ra	359	Ac	360	Th	361	Pa	362	U	363	Np	364	Pu	365	Am	366	Cm	367	Bk	368	Cf	369	Es	370	Lr	371	La	372	Hf	373	Ta	374	W	375	Re	376	Os	377	Ir	378	Pt	379	Au	380	Hg	381	Tl	382	Pb	383	Bi	384	Po	385	At	386	Rn	387	Fr	388	Ra	389	Ac	390	Th	391	Pa	392	U	393	Np	394	Pu	395	Am	396	Cm	397	Bk	398	Cf	399	Es	400	Lr	401	La	402	Hf	403	Ta	404	W	405	Re	406	Os	407	Ir	408	Pt	409	Au	410	Hg	411	Tl	412	Pb	413	Bi	414	Po	415	At	416	Rn	417	Fr	418	Ra	419	Ac	420	Th	421	Pa	422	U	423	Np	424	Pu	425	Am	426	Cm	427	Bk	428	Cf	429	Es	430	Lr	431	La	432	Hf	433	Ta	434	W	435	Re	436	Os	437	Ir	438	Pt	439	Au	440	Hg	441	Tl	442	Pb	443	Bi	444	Po	445	At	446	Rn	447	Fr	448	Ra	449	Ac	450	Th	451	Pa	452	U	453	Np	454	Pu	455	Am	456	Cm	457	Bk	458	Cf	459	Es	460	Lr	461	La	462	Hf	463	Ta	464	W	465	Re	466	Os	467	Ir	468	Pt	469	Au	470	Hg	471	Tl	472	Pb	473	Bi	474	Po	475	At	476	Rn	477	Fr	478	Ra	479	Ac	480	Th	481	Pa	482	U	483	Np	484	Pu	485	Am	486	Cm	487	Bk	488	Cf	489	Es	490	Lr	491	La	492	Hf	493	Ta	494	W	495	Re	496	Os	497	Ir	498	Pt	499	Au	500	Hg	501	Tl	502	Pb	503	Bi	504	Po	505	At	506	Rn	507	Fr	508	Ra	509	Ac	510	Th	511	Pa	512	U	513	Np	514	Pu	515	Am	516	Cm	517	Bk	518	Cf	519	Es	520	Lr	521	La	522	Hf	523	Ta	524	W	525	Re	526	Os	527	Ir	528	Pt	529	Au	530	Hg	531	Tl	532	Pb	533	Bi	534	Po	535	At	536	Rn	537	Fr	538	Ra	539	Ac	540	Th	541	Pa	542	U	543	Np	544	Pu	545	Am	546	Cm	547	Bk	548	Cf	549	Es	550	Lr	551	La	552	Hf	553	Ta	554	W	555	Re	556	Os	557	Ir	558	Pt	559	Au	560	Hg	561	Tl	562	Pb	563	Bi	564	Po	565	At	566	Rn	567	Fr	568	Ra	569	Ac	570	Th	571	Pa	572	U	573	Np	574	Pu	575	Am	576	Cm	577	Bk	578	Cf	579	Es	580	Lr	581	La	582	Hf	583	Ta	584	W	585	Re	586	Os	587	Ir	588	Pt	589	Au	590	Hg	591	Tl	592	Pb	593	Bi	594	Po	595	At	596	Rn	597	Fr	598	Ra	599	Ac	600	Th	601	Pa	602	U	603	Np	604	Pu	605	Am	606	Cm	607	Bk	608	Cf	609	Es	610	Lr	611	La	612	Hf	613	Ta	614	W	615	Re	616	Os	617	Ir	618	Pt	619	Au	620	Hg	621	Tl	622	Pb	623	Bi	624	Po	625	At	626	Rn	627	Fr	628	Ra	629	Ac	630	Th	631	Pa	632	U	633	Np	634	Pu	635	Am	636	Cm	637	Bk	638	Cf	639	Es	640	Lr	641	La	642	Hf	643	Ta	644	W	645	Re	646	Os	647	Ir	648	Pt	649	Au	650	Hg	651	Tl	652	Pb	653	Bi	654	Po	655	At	656	Rn	657	Fr	658	Ra	659	Ac	660	Th	661	Pa	662	U	663	Np	664	Pu	665	Am	666	Cm	667	Bk	668	Cf	669	Es	670	Lr	671	La	672	Hf	673	Ta	674	W	675	Re	676	Os	677	Ir	678	Pt	679	Au	680	Hg	681	Tl	682	Pb	683	Bi	684	Po	685	At	686	Rn	687	Fr	688	Ra	689	Ac	690	Th	691	Pa	692	U	693	Np	694	Pu	695	Am	696	Cm	697	Bk	698	Cf	699	Es	700	Lr	701	La	702	Hf	703	Ta	704	W	705	Re	706	Os	707	Ir	708	Pt	709	Au	710	Hg	711	Tl	712	Pb	713	Bi	714	Po	715	At	716	Rn	717	Fr	718	Ra	719	Ac	720	Th	721	Pa	722	U	723	Np	724	Pu	725	Am	726	Cm	727	Bk	728	Cf	729	Es	730	Lr	731	La	732	Hf	733	Ta	734	W	735	Re	736	Os	737	Ir	738	Pt	739	Au	740	Hg	741	Tl	742	Pb	743	Bi	744	Po	745	At	746	Rn	747	Fr	748	Ra	749	Ac	750	Th	751	Pa	752	U	753	Np	754	Pu	755	Am	756	Cm	757	Bk	758	Cf	759	Es	760	Lr	761	La	762	Hf	763	Ta	764	W	765	Re	766	Os	767	Ir	768	Pt	769	Au	770	Hg	771	Tl	772	Pb	773	Bi	774	Po	775	At	776	Rn	777	Fr	778	Ra	779	Ac	780	Th	781	Pa	782	U	783	Np	784	Pu	785	Am	786	Cm	787	Bk	788	Cf	789	Es	790	Lr	791	La	792	Hf	793	Ta	794	W	795	Re	796	Os	797	Ir	798	Pt	799	Au	800	Hg	801	Tl	802	Pb	803	Bi	804	Po	805	At	806	Rn	807	Fr	808	Ra	809	Ac	810	Th	811	Pa	812	U	813	Np	814	Pu	815	Am	816	Cm	817	Bk	818	Cf	819	Es	820	Lr	821	La	822	Hf	823	Ta	824	W	825	Re	826	Os	827	Ir	828	Pt	829	Au	830	Hg	831	Tl	832	Pb	833	Bi	834	Po	835	At	836	Rn	837	Fr	838	Ra	839	Ac	840	Th	841	Pa	842	U	843	Np	844	Pu	845	Am	846	Cm	847	Bk	848	Cf	849	Es	850