APPENDIX A, Distributions of laboratories in Khartoum State

Table A.1. Distributions of laboratories in Khartoum State

NO	Departments	NUMBER OF LABS
1	federal hospitals	22
2	State Hospitals	24
3	Military Hospitals	17
4	Primary Health care centers	156
5	NGOs laboratories	540
6	private hospitals	94
7	Laboratories and private clinics	610
8	Coefficient of camps	20
Total		1483

APPENDIX B. Data collection questionnaire template for calibration flame photometer.

Questionnaire for ISO Standards of Flame Photometer

Hospital Lab. Name: ……

1- Manufacturing Country …… .
Manufacturer's name …… .
Instrument Model …….. .
Serial Number: …….. .

2- The instrument's details is fully logged book. **Yes** ☐ **No** ☐
3- Who installed it? **Company** ☐ **Technician** ☐ **Other** ☐
4- The user operate the instrument:
After training ☐ **Without training** ☐
5- Environment stability achieved: **Yes** ☐ **No** ☐
6- The Status of the device upon receipt

New ☐ **Reconditioned** ☐
Used ☐ **I don't know** ☐

7- Did you verify manufacture criteria: **Yes** ☐ **No** ☐
8- Calibration process is performed:
i. **Prior to use unless it comes with a calibration certificate** ☐
ii. **After repair** ☐
iii. **Periodic calibration** ☐
iv. **Whenever accuracy is in doubt** ☐
v. **Never** ☐
9- Maintenance process is usually done:
Regularly ☐ **Due to malfunction** ☐
10- The current situation of the instrument is :
Good ☐ **Bad** ☐ **Damaged** ☐
11- Based on the performance of the instrument, do you prefer to:
Still use it ☐ **Replace it as soon as possible** ☐

APPENDIX C. Reading collection tables

Table C.1. Flame photometer readings pre and post calibration

Hospital name …….…… Instrument No ….

Flame Photometer Company ……. **Serial No. :** ……....

No.	Item and its reading											Comment
1.	**Compressor**											
			Standard range (kPa)		DPI reading							
	Compressor pressure		96.53 – 206.85									
2.	**Pressure gauge**											
	The Pressure gauge pre calibration adjusted at											
	Pressure gauge (kPa)		DPI reading (kPa)		The mean							
	50				The mean of readings $\sum X/3 =$							
	100											
	150				% error average =							
	Pressure gauge diversion											
	Pre adjust reading				Post adjust reading							
	Pressure gauge adjusted at (P =14 psi)		DPI reading		Pressure gauge indicator		DPI reading (P = 96.53 kPa)					
	96.53 kPa											
3.	**Atomizer**											
	The pre-adjusted sucking rate of nebulizer											
	Sucking rate per minute		The residual volume of 6 ml		The pressure at nebulizer							
	The sucking rate of nebulizer after calibrating											
	Sucking rate per minute		The residual volume of 6 ml		The pressure at nebulizer							
4.	**Normal control and pathological control readings**											
			Normal control Lot (062A)					**pathological control** Lot (061A)				
Sample No.	**Filter**	**Actual value**	**Range**		**Reading value**	**Final value**		**Actual value**	**Range**		**Reading value**	**Final value**
Sample 1 Not diluted	Na	114	103-126	1×				160	144-176	1×		
	K	4.06	3.65-4.46	1×				7.00	6.30-7.69	1×		
Sample 2 Diluted A	Na	57		2×				80		2×		
	K	2.03		2×				3.5		2×		
Sample 3 Diluted B	Na	28.5		4×				40		4×		
	K	1.015		4×				1.75		4×		
5.	**Pre and post calibration reading for Normal and pathological control**											
			Normal control Lot (062A)					**pathological control** Lot (061A)				
		Filter	**Actual value**	**Range**	**pre**	**post**		**Actual value**	**Range**	**pre**	**post**	
		Na	114	103-126				160	144-176			
		K	4.06	3.65-4.46				7.00	6.30-7.69			

Table C.2. Ion Selective Electrode readings

Hospital name …….…… Instrument No ….

Ion Selective Electrode Company ……..…... **Serial No. :** …..…..….

No.	Transducer	Normal control Lot (062A)		pathological control Lot (061A)		Comment
		Actual value	reading	Actual value	reading	
1.	Na	114		160		
2.	K	4.06		7.00		

APPENDIX D. The certified tools and used materials

Table D.1. DPI calibration certificate

CALIBRATION CERTIFICATE PAGE 1 of 1

GE Druck

UNIT UNDER TEST (UUT)

Manufacturer	: Druck
Type Number	: DPI104
Serial Number	: 3448247
Pressure Range	: 0 to 7 bar g
Pressure Connector	: ¼ BSP Male
Calibration Date	: 19 August 2011

CALIBRATOR INFORMATION

	Calibration Instrument	: DPI515
	Serial Number	: 51501920
(*1)	Calibrated Against	: UKAS Lab.0221
	Calibration Instrument	: 34401A
	Serial Number	: MY45022435
(*1)	Calibrated Against	: UKAS Lab.0221

PRESSURE PERFORMANCE 20°C (*1)

Actual Applied Value bar	Unit Under Test Reading bar (*2)	Unit Under Test Deviation (*3)	Permissible Deviation (*4)
-0.0001	-0.0001	0.000 %fs	±0.035 %fs
1.3997	1.3997	0.000 %fs	±0.035 %fs
2.7998	2.7997	-0.001 %fs	±0.035 %fs
4.1996	4.1997	0.001 %fs	±0.035 %fs
5.5994	5.5994	0.000 %fs	±0.035 %fs
6.9996	6.9997	0.001 %fs	±0.035 %fs
3.5000	3.4997	-0.004 %fs	±0.035 %fs
0.0004	0.0003	-0.001 %fs	±0.035 %fs

ANALOGUE PERFORMANCE 20°C (*1)

Voltage Setpoint %	Analogue Output Reading V (*2)	Unit Under Test Deviation	Permissible Deviation (*4)
2	0.100	-0.006 %fs	±0.095 %fs
20	1.000	-0.010 %fs	±0.095 %fs
40	2.000	0.003 %fs	±0.095 %fs
60	2.999	-0.015 %fs	±0.095 %fs
80	3.999	-0.022 %fs	±0.095 %fs
100	5.000	-0.003 %fs	±0.095 %fs

Certified by: GE D498 Date: 20 AUG 2011

NOTES

(*1) Traceable to relevant International Standards (including N.I.S.T.).
(*2) Actual recorded values. For specification, see Permissible Deviation column.
(*3) Deviation calculated from UUT Reading minus Actual Applied Value.
(*4) Non linearity, hysterisis, temperature effects and repeatability.

PS1074 V1.02

Druck Ltd, Fir Tree Lane, Groby, Leicestershire LE6 0FH. www.gesensing.com

Table D.2. Biochemistry Calibrator

BIOCHEMISTRY CALIBRATOR

LOT 047A

COMPONENT	METHOD	VALUE	UNITS	VALUE	UNITS	TRACEABILITY
ACID PHOSPHATASE	Naphtyl phosphate/pentanediol	18,1	U/L	0,300	µkat/L	BMC
ALBUMIN	Bromocresol green	30,5	g/L	30,5	g/L	SRM 927 c (NIST)
ALKALINE PHOSPHATASE	2-Amino-2-methyl-1-propanol buffer	328	U/L	5,45	µkat/L	BMC
	Diethanolamine buffer	492	U/L	8,16	µkat/L	BMC
ALT/GPT	IFCC without pyridoxal phosphate	99,0	U/L	1,64	µkat/L	BMC
	IFCC with pyridoxal phosphate	103	U/L	1,72	µkat/L	C-RSE/IFCC
α-AMYLASE	IFCC	270	U/L	4,49	µkat/L	C-RSE/IFCC
	Direct substrate	287	U/L	4,76	µkat/L	BMC
AST/GOT	IFCC without pyridoxal phosphate	118	U/L	1,96	µkat/L	BMC
	IFCC with pyridoxal phosphate	134	U/L	2,23	µkat/L	C-RSE/IFCC
BILIRUBIN, DIRECT	Diazoted sulfanilic	1,12	mg/dL	19,2	µmol/L	BMC
BILIRUBIN, TOTAL	Diazoted sulfanilic	3,82	mg/dL	65,3	µmol/L	SRM 909 b (NIST)
CALCIUM	Methylthymol blue	12,1	mg/dL	3,04	mmol/L	SRM 909 b (NIST)
	Arsenazo III	10,7	mg/dL	2,66	mmol/L	SRM 909 b (NIST)
CHLORIDE	Selective electrode	104	mmol/L	104	mmol/L	SRM 909 b (NIST)
CHOLESTEROL	Cholesterol oxidase/peroxidase	186	mg/dL	4,82	mmol/L	SRM 909 b (NIST)
CK	IFCC	320	U/L	5,32	µkat/L	C-RSE/IFCC
CREATININE	Alkaline picrate	3,10	mg/dL	274	µmol/L	SRM 909 b (NIST)
GLUCOSE	Glucose oxidase/peroxidase	173	mg/dL	9,63	mmol/L	BMC
γ-GT	IFCC	144	U/L	2,39	µkat/L	C-RSE/IFCC
IRON	Ferrozine	173	µg/dL	31,0	µmol/L	BMC
	Chromazurol B	62,6	µg/dL	11,2	µmol/L	BMC
LD/LDH	Pyruvate	599	U/L	9,94	µkat/L	BMC
	IFCC	280	U/L	4,64	µkat/L	C-RSE/IFCC
MAGNESIUM	Xylidyl Blue / Calmagite	1,87	mg/dL	0,768	mmol/L	SRM 909 b (NIST)
PHOSPHORUS	Phosphomolybdate/UV	6,73	mg/dL	2,17	mmol/L	BMC
POTASSIUM	Selective electrode	4,95	mmol/L	4,95	mmol/L	SRM 909 b (NIST)
PROTEIN, TOTAL	Biuret	60,2	g/L	60,2	g/L	SRM 927 c (NIST)
SODIUM	Selective electrode	134	mmol/L	134	mmol/L	SRM 909 b (NIST)
TRIGLYCERIDES	Glycerol phosphate oxydase/peroxydase	136	mg/dL	1,54	mmol/L	SRM 909 b (NIST)
UREA	Urease (Color / UV)	84,7	mg/dL	14,1	mmol/L	SRM 909 b (NIST)
URIC ACID	Uricase/peroxidase	7,93	mg/dL	472	µmol/L	SRM 909 b (NIST)

NOTES

The enzymes values (U/L and µkat/L) are for a incubation temperature of 37 ºC.
BMC: BioSystems master calibrator.
C-RSE/IFCC: Traceable to the reference system as described by the IFCC Committee on Reference Systems for Enzymes.

Table D.3. Biochemistry control serum – level - I

BIOCHEMISTRY CONTROL SERUM

LEVEL I LOT 062A

COMPONENT	METHOD	VALUE	RANGE	UNITS	TRACEABILITY
ACID PHOSPHATASE	Naphtyl phosphate/pentanediol	7,32 0,122	3,66 - 11,0 0,061 - 0,182	U/L µkat/L	BMC
ALBUMIN	Bromocresol green	25,8	21,1 - 30,4	g/L	SRM 927 c (NIST)
ALKALINE PHOSPHATASE	2-Amino-2-methyl-1-propanol buffer	155 2,58	127 - 183 2,11 - 3,04	U/L µkat/L	BMC
	Diethanolamine buffer	223 3,70	183 - 263 3,04 - 4,37	U/L µkat/L	BMC
ALT/GPT	IFCC without pyridoxal phosphate	33,4 0,554	27,3 - 39,4 0,454 - 0,653	U/L µkat/L	BMC
	IFCC with pyridoxal phosphate	37,8 0,627	31,0 - 44,6 0,514 - 0,740	U/L µkat/L	C-RSE/IFCC
α-AMYLASE	IFCC	122 2,02	99,9 - 144 1,66 - 2,39	U/L µkat/L	C-RSE/IFCC
	Direct substrate	141 2,34	116 - 166 1,92 - 2,76	U/L µkat/L	BMC
AST/GOT	IFCC without pyridoxal phosphate	44,1 0,732	36,2 - 52,1 0,600 - 0,864	U/L µkat/L	BMC
	IFCC with pyridoxal phosphate	52,7 0,875	43,2 - 62,2 0,717 - 1,03	U/L µkat/L	C-RSE/IFCC
BILIRUBIN, DIRECT	Diazoted sulfanilic	0,636 10,9	0,445 - 0,827 7,61 - 14,1	mg/dL µmol/L	BMC
BILIRUBIN, TOTAL	Diazoted sulfanilic	2,17 37,0	1,78 - 2,56 30,4 - 43,7	mg/dL µmol/L	SRM 909 b (NIST)
CALCIUM	Methylthymol blue	9,76 2,44	8,59 - 10,9 2,15 - 2,73	mg/dL mmol/L	SRM 909 b (NIST)
	Arsenazo III	8,56 2,14	7,54 - 9,59 1,88 - 2,40	mg/dL mmol/L	SRM 909 b (NIST)
CHLORIDE	Selective electrode	83,9	75,5 - 92,2	mmol/L	SRM 909 b (NIST)
CHOLESTEROL	Cholesterol oxidase/peroxidase	149 3,87	127 - 172 3,29 - 4,45	mg/dL mmol/L	SRM 909 b (NIST)
CK	IFCC	180 2,98	144 - 215 2,38 - 3,58	U/L µkat/L	C-RSE/IFCC
CREATININE	Alkaline picrate	1,54 136	1,26 - 1,81 112 - 160	mg/dL µmol/L	SRM 909 b (NIST)
GLUCOSE	Glucose oxidase/peroxidase	84,2 4,68	71,6 - 96,9 3,98 - 5,38	mg/dL mmol/L	BMC
γ-GT	IFCC	39,1 0,649	32,1 - 46,1 0,532 - 0,766	U/L µkat/L	C-RSE/IFCC
IRON	Ferrozine	105 18,7	86,2 - 123 15,4 - 22,0	µg/dL µmol/L	BMC
	Chromazurol B	38,0 6,81	31,4 - 44,7 5,62 - 8,00	µg/dL µmol/L	BMC
LIPASE	Color	68,2 1,13	51,1 - 85,2 0,849 - 1,42	U/L µkat/L	BMC
LDH	Pyruvate	398 6,61	326 - 470 5,42 - 7,79	U/L µkat/L	BMC
	IFCC	175 2,91	144 - 207 2,39 - 3,44	U/L µkat/L	C-RSE/IFCC
MAGNESIUM	Xylidyl Blue / Calmagite	1,20 0,492	0,960 - 1,44 0,393 - 0,590	mg/dL mmol/L	SRM 909 b (NIST)
PHOSPHORUS	Phosphomolybdate/UV	4,17 1,34	3,42 - 4,92 1,10 - 1,58	mg/dL mmol/L	BMC
POTASSIUM	Selective electrode	4,06	3,65 - 4,46	mmol/L	SRM 909 b (NIST)
PROTEIN, TOTAL	Biuret	50,0	44,0 - 56,0	g/L	SRM 927 c (NIST)
SODIUM	Selective electrode	114	103 - 126	mmol/L	SRM 909 b (NIST)
TRIGLYCERIDES	Glycerol phosphate oxydase/peroxydase	51,9 0,586	44,1 - 59,7 0,499 - 0,674	mg/dL mmol/L	SRM 909 b (NIST)
UREA/BUN	Urease (Color / UV)	27,1 4,49	23,0 - 31,1 3,82 - 5,17	mg/dL mmol/L	SRM 909 b (NIST)
URIC ACID	Uricase/peroxidase	5,57 331	4,73 - 6,40 282 - 381	mg/dL µmol/L	SRM 909 b (NIST)

NOTES

The enzymes values (U/L and µkat/L) are for a incubation temperature of 37 ºC.
BMC: BioSystems master calibrator.
C-RSE/IFCC: Traceable to the reference system as described by the IFCC Committee on Reference Systems for Enzymes.

Table D.4. Biochemistry control serum – level - II

BIOCHEMISTRY CONTROL SERUM

LEVEL II LOT 061A

COMPONENT	METHOD	VALUE	RANGE	UNITS	TRACEABILITY
ACID PHOSPHATASE	Naphtyl phosphate/pentanediol	24,6 0,409	12,3 - 37,0 0,205 - 0,614	U/L µkat/L	BMC
ALBUMIN	Bromocresol green	40,0	32,8 - 47,3	g/L	SRM 927 c (NIST)
ALKALINE PHOSPHATASE	2-Amino-2-methyl-1-propanol buffer	351 5,82	287 - 414 4,77 - 6,87	U/L µkat/L	BMC
	Diethanolamine buffer	524 8,69	429 - 618 7,13 - 10,3	U/L µkat/L	BMC
ALT/GPT	IFCC without pyridoxal phosphate	190 3,16	156 - 224 2,59 - 3,73	U/L µkat/L	BMC
	IFCC with pyridoxal phosphate	194 3,22	159 - 229 2,64 - 3,80	U/L µkat/L	C-RSE/IFCC
α-AMYLASE	IFCC	744 12,4	610 - 878 10,1 - 14,6	U/L µkat/L	C-RSE/IFCC
	Direct substrate	770 12,8	631 - 909 10,5 - 15,1	U/L µkat/L	BMC
AST/GOT	IFCC without pyridoxal phosphate	184 3,05	151 - 217 2,50 - 3,60	U/L µkat/L	BMC
	IFCC with pyridoxal phosphate	207 3,43	170 - 244 2,82 - 4,05	U/L µkat/L	C-RSE/IFCC
BILIRUBIN, DIRECT	Diazoted sulfanilic	1,72 29,3	1,20 - 2,23 20,5 - 38,1	mg/dL µmol/L	BMC
BILIRUBIN, TOTAL	Diazoted sulfanilic	6,20 106	5,08 - 7,31 86,9 - 125	mg/dL µmol/L	SRM 909 b (NIST)
CALCIUM	Methylthymol blue	13,5 3,36	11,8 - 15,1 2,96 - 3,77	mg/dL mmol/L	SRM 909 b (NIST)
	Arsenazo III	11,8 2,95	10,4 - 13,2 2,60 - 3,30	mg/dL mmol/L	SRM 909 b (NIST)
CHLORIDE	Selective electrode	128	115 - 141	mmol/L	SRM 909 b (NIST)
CHOLESTEROL	Cholesterol oxidase/peroxidase	242 6,28	206 - 279 5,34 - 7,22	mg/dL mmol/L	SRM 909 b (NIST)
CK	IFCC	503 8,36	403 - 604 6,69 - 10,0	U/L µkat/L	C-RSE/IFCC
CREATININE	Alkaline picrate	4,67 413	3,83 - 5,51 339 - 488	mg/dL µmol/L	SRM 909 b (NIST)
GLUCOSE	Glucose oxidase/peroxidase	264 14,7	224 - 304 12,5 - 16,9	mg/dL mmol/L	BMC
γ-GT	IFCC	223 3,71	183 - 263 3,04 - 4,37	U/L µkat/L	C-RSE/IFCC
IRON	Ferrozine	214 38,3	177 - 252 31,6 - 45,0	µg/dL µmol/L	BMC
	Chromazurol B	77,9 13,9	64,3 - 91,6 11,5 - 16,4	µg/dL µmol/L	BMC
LIPASE	Color	118 1,95	88,2 - 147 1,46 - 2,44	U/L µkat/L	BMC
LDH	Pyruvate	733 12,2	601 - 865 9,98 - 14,4	U/L µkat/L	BMC
	IFCC	348 5,78	286 - 411 4,74 - 6,82	U/L µkat/L	C-RSE/IFCC
MAGNESIUM	Xylidyl Blue / Calmagite	2,94 1,21	2,35 - 3,53 0,964 - 1,45	mg/dL mmol/L	SRM 909 b (NIST)
PHOSPHORUS	Phosphomolybdate/UV	8,93 2,88	7,32 - 10,5 2,36 - 3,39	mg/dL mmol/L	BMC
POTASSIUM	Selective electrode	7,00	6,30 - 7,69	mmol/L	SRM 909 b (NIST)
PROTEIN, TOTAL	Biuret	79,1	69,6 - 88,6	g/L	SRM 927 c (NIST)
SODIUM	Selective electrode	160	144 - 176	mmol/L	SRM 909 b (NIST)
TRIGLYCERIDES	Glycerol phosphate oxydase/peroxydase	211 2,39	180 - 243 2,03 - 2,75	mg/dL mmol/L	SRM 909 b (NIST)
UREA/BUN	Urease (Color / UV)	146 24,2	124 - 168 20,6 - 27,9	mg/dL mmol/L	SRM 909 b (NIST)
URIC ACID	Uricase/peroxidase	9,53 568	8,10 - 11,0 482 - 653	mg/dL µmol/L	SRM 909 b (NIST)

NOTES

The enzymes values (U/L and µkat/L) are for a incubation temperature of 37 °C.
BMC: BioSystems master calibrator.
C-RSE/IFCC: Traceable to the reference system as described by the IFCC Committee on Reference Systems for Enzymes.