LABOR FÜR RADIO- UND UMWELTCHEMIE
DER UNIVERSITÄT BERN UND
DES PAUL SCHERRER INSTITUTS

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# Introduction to the SHE Chemistry

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## Past, Present & Future

**Chemistry of Z=104-108**

**Hot fusion**

($^{18}O$, $^{22}Ne$, $^{26}Mg$)

Liquid Phase (104-106)

Gas Phase (104-108)

**Cold fusion**

($^{50}Ti$)

Liquid Phase (104-105) (*SISAK*)

## Present & Future

**Chemistry of Spherical SHE Z=109-118**

**Warm fusion**

($^{48}Ca$)

Gas Phase (112)

Liquid Phase (?)

## Production of spherical SHE nuclides for chemical study ($T_{1/2} > 1$ s) in $^{48}Ca$ induced fusion reactions (3,4n-channels)

| Nuclide | $T_{1/2}$ | Target | Formation |
|---|---|---|---|
| $^{278}Mt$ | 35 s* | $^{249}Bk$ | Indirect |
| $^{280}110$ | 8 s (sf) | $^{244}Pu$ | Indirect |
| $^{282}111$ | 3.5 h* | $^{249}Bk$ | Indirect |
| **$^{283}112$** | **3 min(sf)** | **$^{238}U$** | **Direct** |
| $^{284}113$ | 1 h* | $^{243}Am$ | Indirect |
| **$^{287}114$** | **5 s** | **$^{244}Pu$** | **Direct** |
| **$^{288}115$** | **21 s*** | **$^{243}Am$** | **Direct** |

- * *Moeller (1997)*

LABORATORY FOR RADIOCHEMISTRY AND ENVIRONMENTAL CHEMISTRY OF THE UNIVERSITY OF BERN AND THE PAUL SCHERRER INSITUTE

# The periodic table of the elements

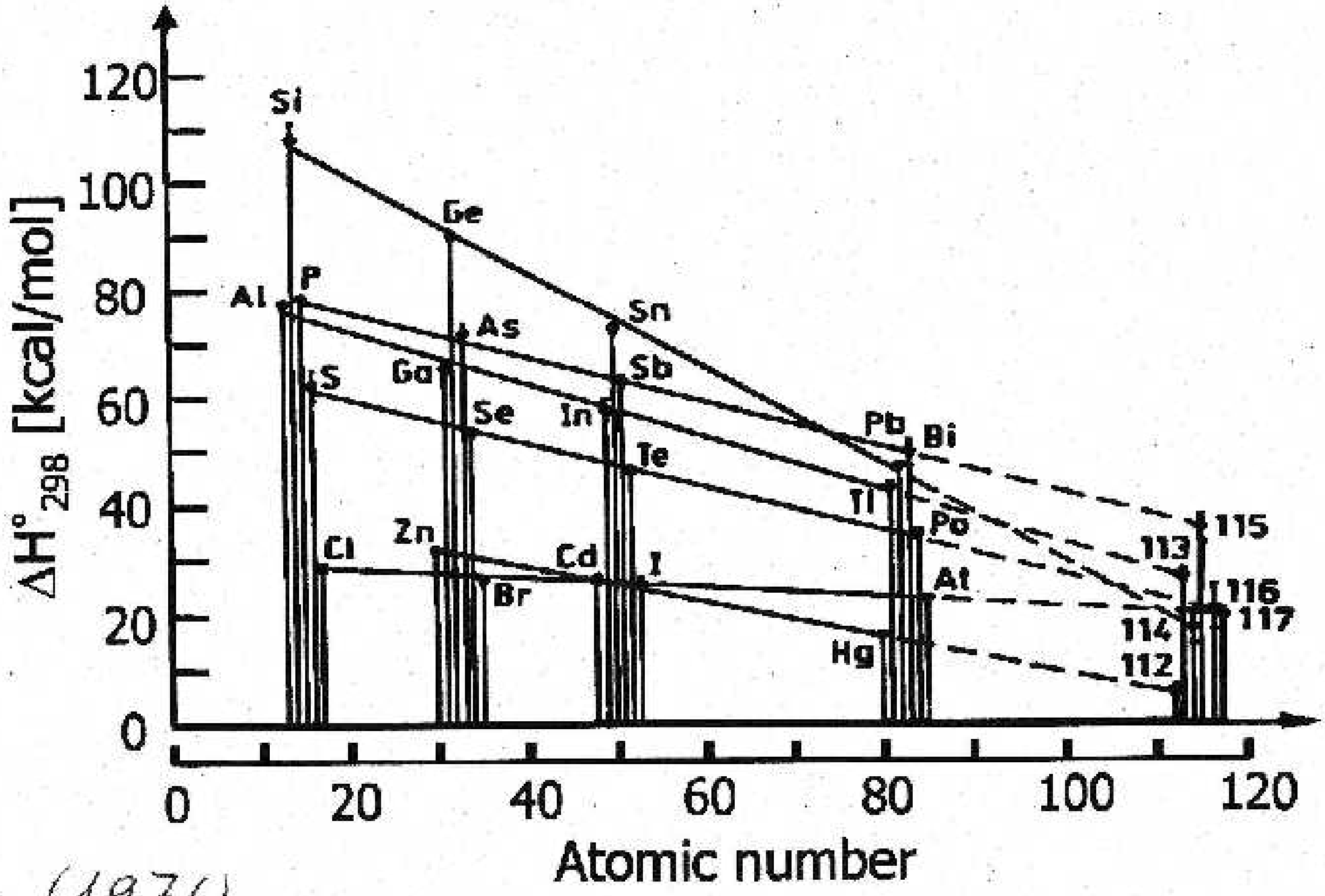
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 H | | | | | | | | | | | | | | | | | 2 He |
| 3 Li | 4 Be | | | | | | | | | | | 5 B | 6 C | 7 N | 8 O | 9 F | 10 Ne |
| 11 Na | 12 Mg | | | | | | | | | | | 13 Al | 14 Si | 15 P | 16 S | 17 Cl | 18 Ar |
| 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 | | 72 Hf | 73 Ta | 74 W | 75 Re | 76 Os | 77 Ir | 78 Pt | 79 Au | 80 Hg | 81 Tl | 82 Pb | 83 Bi | 84 Po | 85 At | 86 Rn |
| 87 Fr | 88 Ra | | 104 Rf | 105 Db | 106 Sg | 107 Bh | 108 Hs | 109 Mt | 110 Uun | 111 Uuu | 112 Uub | | 114 Uuq | | 116 Uuh | | |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 57 La | 58 Ce | 59 Pr | 60 Nd | 61 Pm | 62 Sm | 63 Eu | 64 Gd | 65 Tb | 66 Dy | 67 Ho | 68 Er | 69 Tm | 70 Yb | 71 Lu |
| 89 Ac | 90 Th | 91 Pa | 92 U | 93 Np | 94 Pu | 95 Am | 96 Cm | 97 Bk | 98 Cf | 99 Es | 100 Fm | 101 Md | 102 No | 103 Lr |

S. Soverna, Jan. 2002

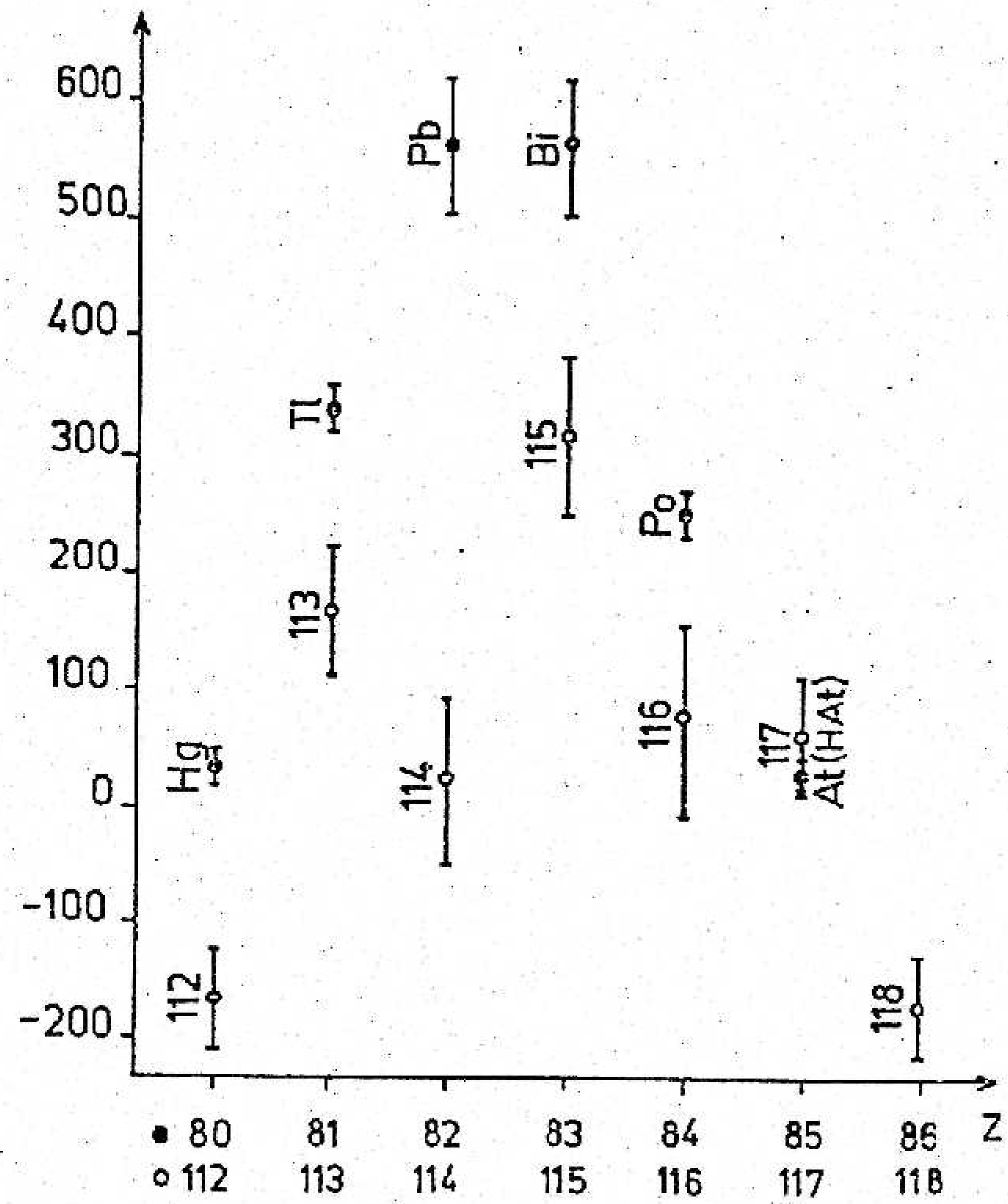
# Extrapolation of the standard enthalpies for SHE

Standard enthalpies of gaseous monoatomic elements

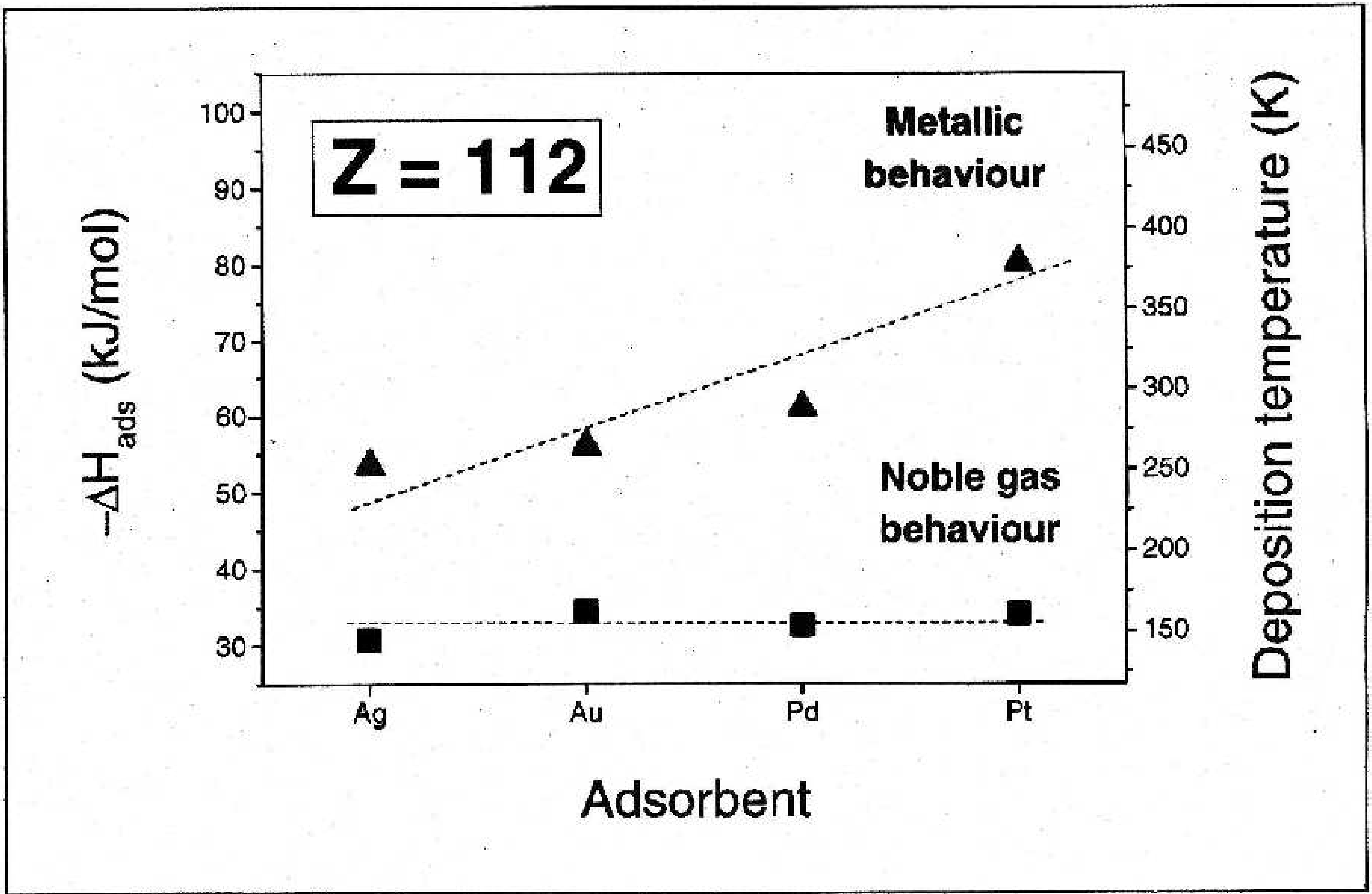


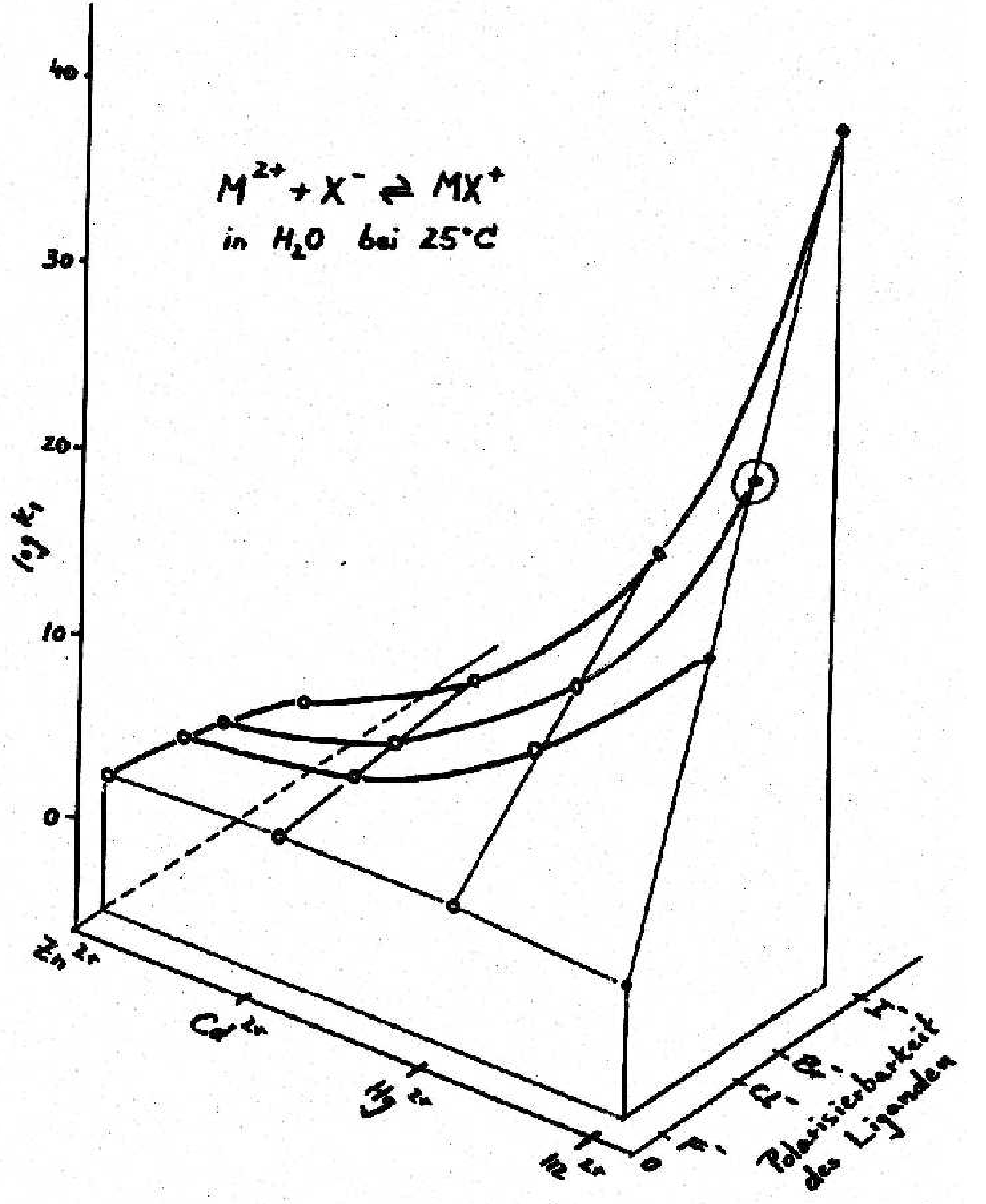

B. Eichler (1976)

# Deposition Temp. of 6p & 7p - Elements on Quartz




B. Eichler, (1976), unpublished


Z = 112
Metallic behaviour
Noble gas behaviour
100
90
80
70
60
50
40
30
−ΔH_ads (kJ/mol)
450
400
350
300
250
200
150
Deposition temperature (K)
Ag
Au
Pd
Pt
Adsorbent




J.V. Kratz et al.

# Ongoing and planned chemistry experiments with spherical SHE's

⇒ A. Yakushev et al.: Element 112 (Evidence for a behaviour like a very volatile noble metal or noble gas)

⇒ S. Soverna et al.: Element 112 (Scheduled experiment to measure volatility)

⇒ A. Yakushev et al.: Element 114 (Planned experiment to study element 114 via detection of its decay product 112 in a gas chemical experiment)

⇒ R. Eichler et al.: Element 114 (First ideas on a gas chemical study of element 114)

# Production of element 112

Nuclear reaction: $^{238}U(^{48}Ca,3n)^{283}112^*$

sf ($T_{1/2} \approx 3$ min)

# Expected event-rate of element 112

- Over all efficiency of IVO: 50 %
- Average beam intensity: 1 pμA
- Target thickness: 1 mg/cm$^2$
- Expected production cross section 1 pb

→ **4 detected $^{283}$112 fission events per week**

# Detection of SF-decaying nuclides enables assignment to a given species if a deposition peak is observed.

Example: $HsO_4$